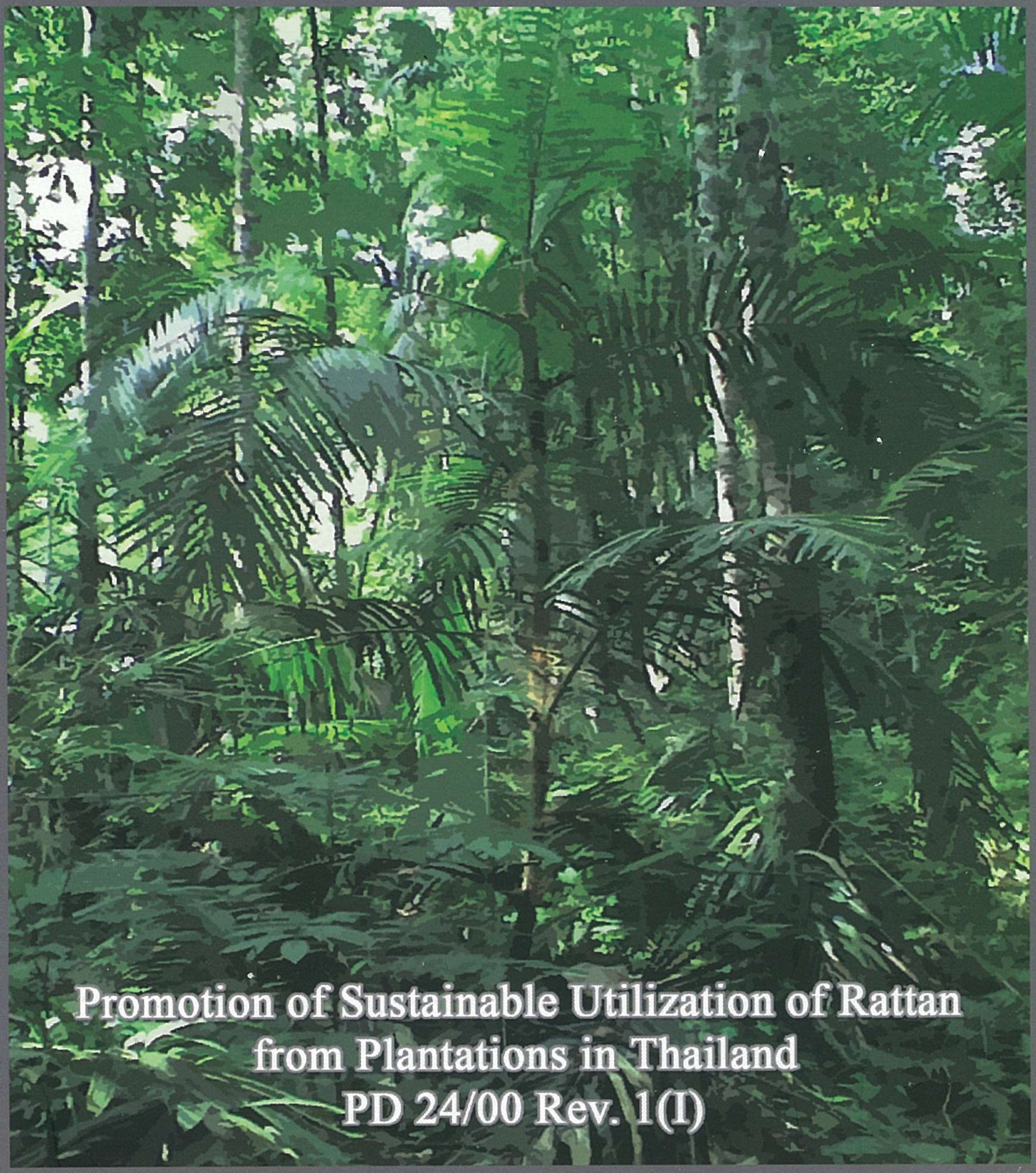
Final Technical Reports



Promotion of Sustainable Utilization of Rattan from Plantations in Thailand
PD 24/00 Rev. 1(I)

Royal Forest Department
and
International Tropical Timber Organization

ITTO

FINAL TECHNICAL REPORT

Project : PD24/00 Rev.1(I)
Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

Royal Forest Department
International Tropical Timber Organization
Bangkok, Thailand

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PREFACE

The Royal Forest Department has the policy to promote the establishment and development of commercial plantations, which are regarded to be an important source of income of the rural people as well as a supply of raw material for local industries. This will lead to future development of our national economy.

The rattan palm has become symbolic of the importance of non-wood forest product. It was once a very low value product meant for expensive and often traditional furniture for the rural dwelling population. Nowadays, it has developed into much a sought after high value raw material, meant for designers made goods to grace the homes of the urban middle class. With the advantage of added value has developed the disadvantage of over exploitation and diminishing supply. In fact, the vale of rattan is increasing significantly year by year. Because of this reason and together with the growing demands for rattan in Thailand and in the world, establishment of rattan plantations is the only alternative to create more supply of rattan raw material. However, some problems and obstacles still exist and slow down the effort of everyone concerned in the planning of successful rattan plantations.

In recognition of the importance of rattan, and, with strong desire to search for appropriate guidelines for successful establishment of rattan plantations, the **Royal Forest Department** and the **National Park, Wildlife and Plant Conservation Department of Thailand** have received the support from the **International Tropical Timber Organization (ITTO)** to undertake the research an development project on Promotion of Sustainable Utilization of Rattan from Plantation in Thailand. The project covers the period from the years 2000 to 2004. Technical reports, internal reports, workshop proceedings, manuals are produced for extension purposes and as a basis for future research and development of rattan resources in Thailand and elsewhere.

On behalf of the **Royal Forest Department** and the **National Park, Wildlife and Plant Conservation**, I would like to express our sincere thanks to the **International Tropical Timber Organization (ITTO)** and the government of **Japan** for the support. Special thanks are given to **Dr. Hwan Ok Ma**, ITTO Projects Manager, for his constant support during the entire course of the project. The strong effort and contributions of all project staff to produce the fruitful outcomes also deserve special acknowledgment.

Chatchai Ratanophat
Director General
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ABSTRACT

With the support of the International Tropical Timber Organization (ITTO) Project PD 24/00 Rev. 1(I), Thailand conducted the research work on sustainable management and utilization of rattan. Three demonstration plots for sustainable management of rattan were established at Sakon Nakhon, Krabi and Narathiwat provinces. At Sakon Nakhon, the study was focused on the plantation of 3 rattan species for edible shoots, namely *Calamus viminalis*, *C. siamensis* and *C. tenuis*. In Krabi and Narathiwat, the study was emphasized on yield and practical methods for sustainable management of rattan canes. The experimental plots in Krabi were located in 12-year-old plantation of *Calamus latifolius* and *C. longisetus* mixed-planting with *Azadirachta excelsa*. In Narathiwat, the plot was laid out in a natural forest where *Calamus caecius* grows naturally and some of them had been inter-planted within the area. The study on shoot production was taken place in two rattan plantations of *C. caesius* and *C. siamensis* in Sakon Nakhon province, and in Songkhla province for *C. manan* and *C. caesius* cane production.

The training workshop on Processing and Packaging of Rattan Shoot, Rattan Weaving and Furniture Making, and New Design of Rattan Furniture Making were organized for the local people in Sakon Nakhon, Lampang, Nakhon Ratchasima and Ratchaburi provinces. The small cooperatives for furniture and weaving of rattan products made by the trainee group on rattan weaving and furniture making in Ratchaburi province was initiated. The products of the group have been awarded the 4-star OTOP (One Tambon One Product) under the government's promotion. The products of the group have also been presented in various fairs and festivals.

The research work aims to produce the necessary information on sustainable management of rattan, physical and mechanical properties, shoot processing, protection, soil properties and photosynthetic performance. The research results presented in this report as well as in the internal papers are also available on the Project's Website: **http://www.forest.go.th/rattan**.

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INTRODUCTION

Background

As Thailand has banned logging since 1989, the products of the forest at present are mainly NWFPs. These products include rattan that has been traditionally utilized as materials for weaving, furniture, carpet, blind and many others. Rattans generate employment, extra income subsistence for people, particularly those who live in the rural areas. Rattan resources that used to be adequate in the past are currently being shortage due to deforestation and over harvesting. The lack of rattan raw materials causes Thailand spending a great amount of money for cane importation. From 1995-1997, Thailand had spent approximately US$ 2.5 million yearly for importing rattan cane. At present, banning of the exportation of raw rattan canes from neighboring countries cause a great difficulty for Thai rattan industries. As there is still extensive demands on rattan raw materials in Thailand, promotion for establishment of commercial as well as small-scale rattan plantations needs to be taking into an urgent consideration. Pilot scale plantation of rattans should, therefore, be established and developed for sustainable high yield. There is also a need to develop high quality rattan products to help increasing income of the farmers, to provide a more benefit mean of utilizing rattan as well as to increase value of rattan trade of the country.

With the support of the International Tropical Timber Organization (ITTO) Project PD 24/00 Rev. 1(I), Thailand, the research team conducted the research on sustainable management and utilization of rattan. The training workshop on Processing and Packaging of Rattan Shoot, Rattan Weaving and Furniture Making, and New Design of Rattan Furniture Making were organized for local people aiming to develop the skills of them to make rattan products with appropriate technology. The research findings can be used as an appropriate technologies on management of rattan plantation in Thailand to gain sustainable productivity as well as to seek for efficient and diversified utilization and proper marketing of rattan products in order to contribute to the socio-economic development of the rural communities and the conservation of the rattan diversity and the tropical forest resources in Thailand.

Project Objectives

(1) To study and develop techniques for managing rattan plantations for

sustainable production with a view to developing and disseminating guidelines and technologies on plantation management and harvesting of rattan.

(2) To promote the efficient utilization of rattan shoots and canes for value-added products by developing guidelines for utilization of rattan and transferring technologies to support socio-economic development as well as establishment of community-owned enterprises.

Purpose of the Report

This report is intended to be used as a guideline for sustainable management and utilization of rattan. It is expected that the knowledge gained from the studies will help develop means to produce value-added rattan products. This report includes the results of the research and a synthesis of several internal technical reports and proceedings prepared during the project implementation. These internal reports are available on the Project's website: http://www.forest.go.th/rattan.

This report is prepared by Ms. Pannee Denrungruang, the project leader, and edited by Dr. Songkram Thammicha and Dr. Ladawan Puaugchit.

Yield of 13-15 Years Old, *Calamus longisetus* and *Calamus latifolius* in *Azadirachta excelsa* Plantation

by

Chanatip Kuldilok

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Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

Royal Forest Department
Thailand

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Yield of 13-15 Years Old, *Calamus longisetus* and *Calamus latifolius* in *Azadirachta excelsa* Plantation

Chanatip Kuldilok[1]

Yield of 13-15-year-old Calamus longisetus and Calamus latifolius planted in Azadirachta excelsa plantation was studied at Nai Chong Seed Production Area station, Krabi province. Results showed that C. longisetus and C. latifolius at 13, 14 and 15 years old in the plot without fertilizer applied produce an average length of 17.77, 19.34, 23.68 m, and 25.21, 26.98, 29.52 m, respectively while those with fertilizer applied produce an average length of 10.65, 13.64, 15.33 m and 29.81, 34.56, 35.34 m, respectively. Means annual increment of C. longisetus and C. latifolius in plot without and with fertilizer were 2.96, 2.34 m/year and 2.16, 2.77 m/year, respectively. Survival rates of C. longisetus and C. latifolius were 89% and 91%, respectively. Ratio of merchantable length of C. longisetus was 55% of total length while that in C. latifolius was 60%. Merchantable length of C. longisetus and C. latifolius can be calculated as 565.76, 612.63, 746.54 and 1,085.93, 1,178.30, 1,244.78 m/rai in 13, 14 and 15 years old rattan, respectively. It can be concluded that C. latifolius grew better and produced more production than C. longisetus in all aspects.

INTRODUCTION

There are various rattan species growing in every region of Thailand, but mostly intensity in the southern region as the area is mostly composted of evergreen and tropical rain forest. The northeastern region also has been occupied by various rattan species.

In the past, Thailand is very prosperous with rattan resources of which have been used for weaving to make various containers and utensils, and tying for

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construction purposes. In the mean time rattan utilization has been developed to make household products like table, chair, bed and cabinet. With this development in the utilization it creates high demand for rattan raw material and causing high price. The high demand, improper harvesting management and over exploitation, lead to low production of rattan from the natural forest. The reduction of the forest cover area is also the major cause of intense low supply of rattan raw materials in the country.

Rattan is an important raw material for furniture industry and OTOP products, of which local knowledge is combined with new technology to create many versatile products that can generate an income for the country annually. Now the raw material for this purpose has to depend on importation. Rattan furniture is also important for the country economy as it is very popular in various countries like Canada, European countries and the United Stated. This is because, the rattan furniture has unique characteristic for almost unlimited diversity and versatile design that made it has more advantage than wood. Beside these, it has light weight easy to move and in general the price is lower than wooden furniture.

There are not so many research and plantation establishment on rattan. The growth of rattan in the plantation and under natural forest has not yet been intensive studied in Thailand. Malaysia, Indonesia and the Philippines have many researches and studies on rattan, beginning with seed germination seedling preparation and growth. In Malaysia, there is an extension program for planting of rattan in the rubber plantation especially *Calamus manan* has been planted till harvesting for utilization. In Thailand the promotion for planting of economic rattan species is the forest plantation of the government and private sector can increase commercial rattan plantation. By this mean the existing forest plantation areas can be used more effectively for both trees and rattan production of which more return can be obtained from both government and private plantation. The dependence of rattan from importation could be reduced in the future.

Calamus longisetus and *Calamus latifolius* are large-cane species suitable for making rattan furniture frame which is in high demand by furniture industry. The information from the establishment of rattan seed production area at Krabi showed that rattan planting in the forest plantation grew better than those planted in the natural forest. The objective of the study was to observe growth performance and cane production *of C. longisetus* and *C. latifolius* planting under *Azadirachta* *excelsa* plantation in Krabi province. The results obtained from this study can be base line information for rattan planting under agroforestry system in the future.

MATERIAL AND METHODS

Experimental Site

The experimental plots of this study were located in *C. longisetus* and *C. latifolius* plantation established as rattan seed orchard by intercropped with *Azadirachta excelsa* plantation at Nai Chong, Krabi province at latitude 8° 10′N and longitude 98° 51′E with an elevation of 50 m above mean sea level. The average annual precipitation is 2,500 ± 500 mm.

The *Azadirachta excelsa* plantation was established in 1987 with 4 x 4 m spacing. Two years later, two species of rattan, *C. longisetus* and *C. latifolius*, were planted in the middle of the rows of *Azadirachta excelsa* (Figure 1). The planting area for *C. longisetus* was 52 rai and 20 rai for *C. latifolius*. The first year maintenance was taken place 2 months after planting with total weeding and sub-soiling together with the application of 1 tablespoon of 15-15-15 chemical fertilizer around each rattan plant.

Weeding was done twice a year at the second year till the sixth year, and one time a year afterward. The results of study by Kuldilok (1997) revealed that soil in this *Azadirachta excelsa* plantation was unfertile with an average height of 14.44 m and average crown cover of 83% at 10 years old.

Methods

Sample Plots for Fertilizer Experiment

The experimental plots of 20 x 20 m were located in rattan plantation with 25 rattan clusters in each plot. There were 4 experimental plots for each rattan species, *C. longisetus* and *C. latifolius*: two control plots and other two with fertilizer treatment by the application (1 kg of 16-8-4 chemical fertilizer per plot) in May 2002 and September 2003.

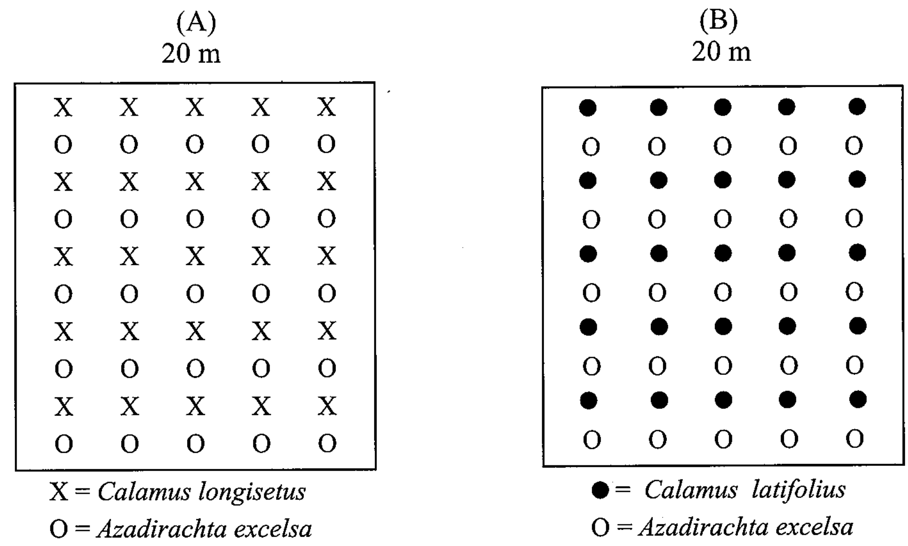

Figure 1. Lay-out of experimental plot in study area. (A) *Calamus longisetus* in *Azadirachta excelca* plantation, spacing 4 x 4 m, (B) *Calamus latifolius* in *Azadirachta excelca* plantation, spacing 4 x 4 m.

Data Collection

The data on growth performance of rattan in the experimental plots were collected in January 2002, 2003 and 2004. The number and length of each cane from all clumps were recorded together with sucker number in the clumps. The canes which were shorter than 1 m, was recorded as suckers. In 2004 thirty canes from each experimental plots were randomly selected from length class 3 (9.00 – 13.50 m), class 4 (13.50 – 18.00 m), class 5 (18.00 – 22.50 m) and class 6 (22.50 – 27.00 m) for harvesting to study on cane size, total length and commercial length to determine commercial proportion of rattan cane.

Data analysis

The cane length was classified into 8 classes, according to marketing requirement for which minimum length was 4.5 m, as follows: 1.0 – 4.5, 4.5 – 9.0, 9.0 – 13.5, 13.5 – 18.0, 18.0 – 22.5, 22.5 – 27.0, 27.0 – 31.5 and 31.5 - 36.0 m. This was the distribution of length classes of all canes in the clump at the age of 13, 14 and 15 years.

Growth rate as determined by mean annual increment and absolute growth is calculated by the following equation.

$$\Delta L = (Lt_2 - Lt_1) / t_2 - t_1$$

Lt_1 and Lt_2 is the length of cane at time t_1 and t_2 (Jintana, 2002).

The commercial proportion of the canes at each age class is the ratio between the length of fully mature part and total length of the cane. The mature part of the cane is the bottom part without leaf sheath or with dry leaf sheath, while the upper part of the cane is covered with fresh leaf sheath. The canes of *C. longisetus* and *C. latifolius* were longer than 8 m in all the sampling clusters.

RESULTS AND DISCUSSION

Rattan Growth

The length growth of *C. longisetus* in control plots is presented in Table 1 and Figure 2 for control, and Table 2 and Figure 3 for plots with fertilizer treatment. The results from control plots revealed that at 13 years old most of the canes were in length class 1, *i.e.*, 51.43% were 1.0 - 4.5 m long and 15.25%, 10.48%, 9.52%, 7.62%, 3.80% and 1.90% were in classes 2, 5, 3, 6, 4, and 7, respectively.

At 14 years old, 48.20% of the canes in control plots were in length class 1, 1.0 – 4.5 m, and 20.54%, 9.82%, 7.14%, 5.36%, 2.68% and 0.84% were in length classes 2, 3, 7, 5, 6, 4 and 8, respectively. However, at the age of 15 years, 35.24% of the canes were in length class 2 (4.5 – 9.0 m), the smaller part being 28.57%, 11.43%, 6.67%, 5.71%, 4.76% and 2.86% were in length classes 1, 3, 4, 6, 7, 8 and 5, respectively.

The results from fertilizer treatment plots are presented in Table 2 and Figure 3. It was found that at the age of 13 years more canes were in length class 1 (48%) and the others being in classes 2, 4, 5, 3 and 6 with 16.07%, 12.50%, 12.50%, 8.90% and 1.79%, respectively. At 14 years of age, more canes were in length class 1 (53.73%), the others being in classes 2, 3, 5, 4, 6 and 7 with 11.95%, 10.45%, 10.45%, 5.97% and 1.49%, respectively. For the 15-year-old rattan, more canes were in length class 1 (38.46%) and the lower part were in length classes 2, 3, 5, 6, 4, 7 and 8 with 21.45%, 12.31%, 9.23%, 7.69%, 6.15%, 3.08% and 1.5%, respectively.

Table 1. Classification of growth of *Calamus longisetus* by commercial length in control plots

Length class	13 years old		14 years old		15 years old	
	Number	%	Number	%	Number	%
1	54	51.43	54	48.21	30	28.57
2	16	15.24	23	20.54	37	35.24
3	10	9.52	11	9.82	12	11.43
4	4	3.81	3	2.68	7	6.67
5	11	10.48	6	5.36	3	2.86
6	8	7.62	6	5.36	6	5.71
7	2	1.90	8	7.14	5	4.76
8	-	-	1	0.89	5	4.76
Total	105	100	112	100	105	100

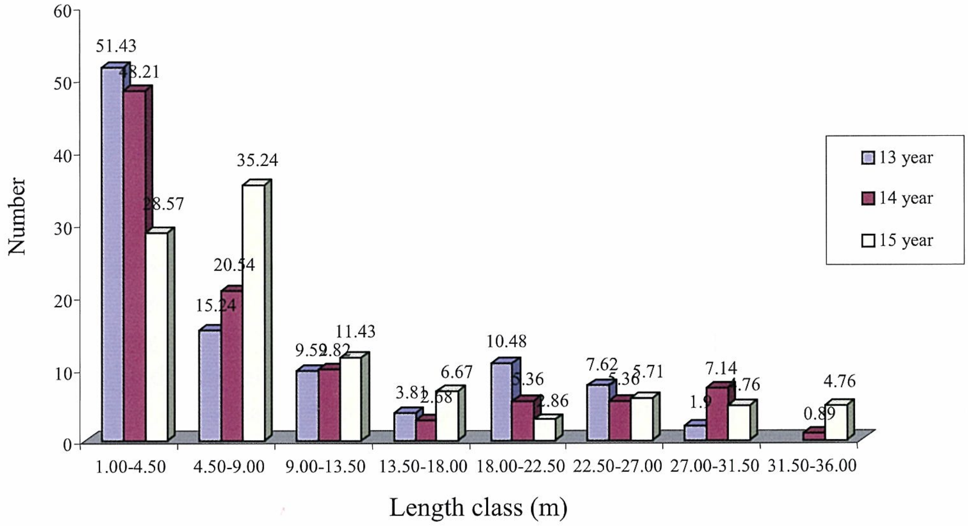

Figure 2. Growth of 13-15-year- old *Calamus longisetus* by commercial length in control plots.

Table 2. Classification of growth of *Calamus longisetus* by commercial length in fertilizer treatment

Length class	13 years old		14 years old		15 years old	
	Number	%	Number	%	Number	%
1	27	48.21	36	53.73	25	38.46
2	9	16.07	8	11.94	14	21.51
3	5	8.93	7	10.45	8	12.31
4	7	12.50	4	5.97	4	6.15
5	7	12.50	7	10.45	6	9.23
6	1	1.79	4	5.97	5	7.69
7	-	-	1	1.49	2	3.08
8	-	-	-	-	1	1.54
Total	56	100	67	100	65	100

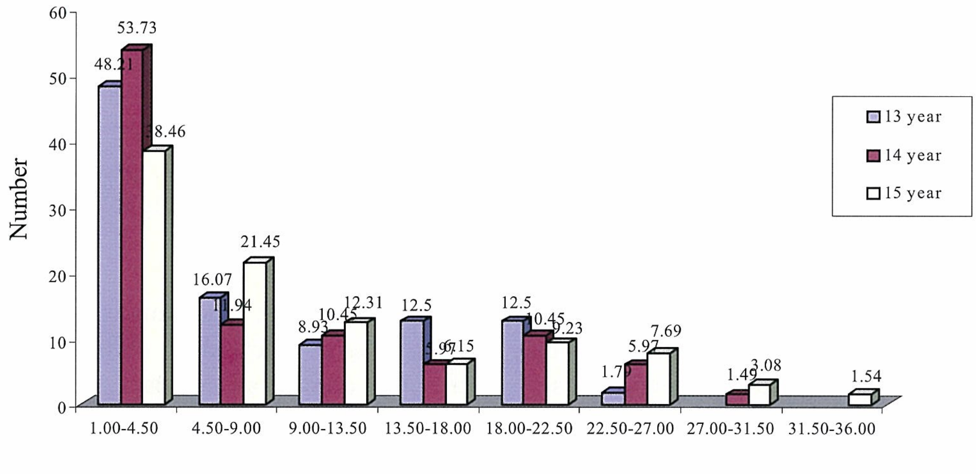

Figure 3. Growth of 13-15-year-old *Calamus longisetus* by commercial length in fertilizer treatment.

The cane growth of *C. latifolius* in the control plots as presented in Table 3 and Figure 4 revealed that at 13 years old most of the canes were in length class 1 (57.56%), the others being in length classes 2, 3, 4, 5, 6 with 12.79%, 12.21%, 11.05%, 4.07% and 2.32%, respectively. At 14 years of age, most of the canes in length class 1 (46.82%) and the rest being 26.89%, 9.83%, 7.51%, 6.94%, 1.73% and 0.58% were in length classes 2, 4, 5, 3, 6 and 7, respectively. At the age of 15 years, 35.58% of canes were in length class 1, the others being in length classes 2, 3, 4, 5, 7 and 6 with 35.97%, 10.43%, 6.75%, 6.75%, 3.05% and 2.45%, respectively.

The growth of *C. latifolius* in the fertilizer treatment plots is presented in Table 4 and Figure 5. At the age of 13 years, the majority of canes were in length class 1 (49.44%), the rest being 17.42%, 12.36%, 11.25%, 6.74% and 2.80% respectively in classes 2, 3, 4, 5 and 6. At 14 years old, more canes were in class 1 (44.02%) and the others were in classes 2, 3, 4, 5, 6 and 7 with 19.56%, 14.13%, 8.70%, 7.61%, 4.89% and 1.09%, respectively. At 15 years of age, more canes were found in length class 1 (37.15%), the others being in classes 2, 3, 4, 5, 6 and 7 with 26.29%, 16.50%, 6.86%, 6.86%, 4.00% and 2.28%, respectively.

In control plots, *C. longisetus* at the age of 13 and 14 years had more canes in length class 1, followed by those in class 2, but at 15 years old more canes were in class 2. In case of fertilizer plots, rattan at the age of 13, 14 and 15 years had more canes in class 1 followed by those in class 2. Similar performance was found in case of *C. latifolius* in the control plots at the age of 13, 14 and 15 years. These results were different from those of 8-year-old rattan in the study of Kuldilok (2000).

At 8 years of age, both *C. longisetus* and *C. latifolius* had similar pattern of growth performance, *i.e.*, more canes were in class 2 followed by class 3. At 9 years old, more canes were in class 3 followed by class 2, and in class 3 followed by class 4 in case of 10-year-old rattan. The pattern of cane length distribution according to previous studies revealed that more canes moved to length class of the previous studied showed that the class of the most cane will shift to higher length class as the plant were older.

Growth Performance

At 13, 14 and 15 years old, *C. longisetus* in the control plots had average cane length of 17.77, 19.34 and 23.68 m respectively, compared to 10.65, 13.64 and 15.33 m of those in fertilizer plots. The average length and mean annual increment (MAI) are presented in Table 5 and Figure 6. Mean annual increment of

Table 3. Classification of growth of *Calamus latifolius* by commercial length in control plots

Length class	13 years old		14 years old		15 years old	
	Number	%	Number	%	Number	%
1	99	57.56	81	46.82	58	35.68
2	22	12.79	46	26.59	57	34.97
3	21	12.21	12	6.94	17	10.43
4	19	11.05	17	9.83	11	6.75
5	7	4.07	13	7.51	11	6.75
6	4	2.32	3	1.73	4	2.45
7	-	-	1	0.58	5	3.07
Total	172	100	173	100	163	100

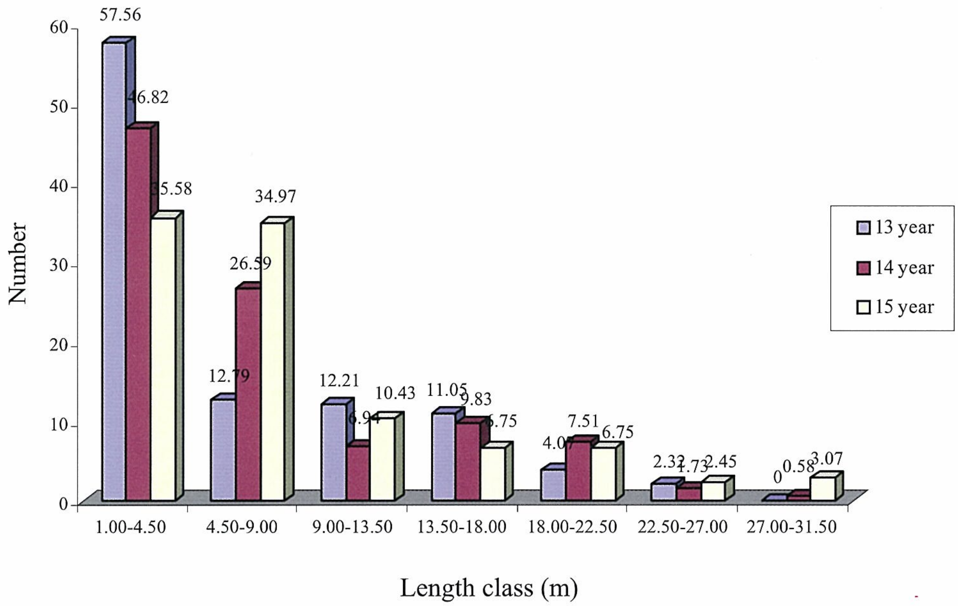

Figure 4. Growth of 13 – 15-year- old *Calamus latifolius* by commercial length in control plot.

Table 4. Classification of growth of *Calamus latifolius* from commercial length in fertilizer treatment

Length class	13 years old		14 years old		15 years old	
	Number	%	Number	%	Number	%
1	88	49.44	81	44.02	65	37.14
2	31	17.42	36	19.56	46	26.29
3	22	12.36	26	14.13	2*9	16.57
4	20	11.24	16	8.70	12	6.86
5	12	6.74	14	7.61	12	6.86
6	5	2.8	9	4.89	7	4.00
7	-	-	2	1.09	4	2.28
Total	178	100	184	100	175	100

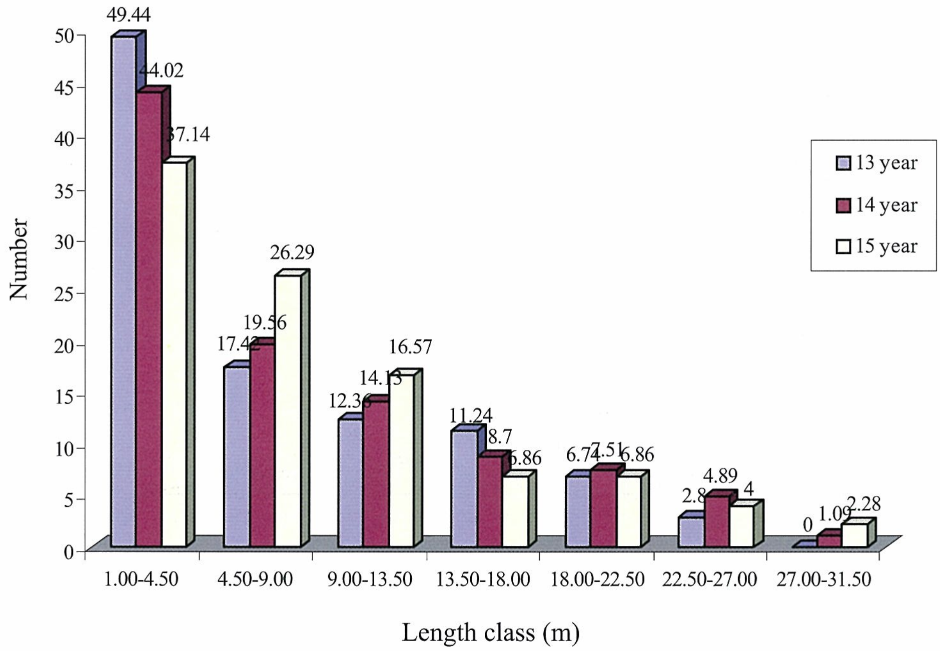

Figure 5. Growth of 13-15-year-old *Calamus latifolius* by commercial length in fertilizer treatment

Table 5. Average mean length (AML) and mean annual increment (MAI) of 13-15-year-old *Calamus longisetus*

Age	Control		Fertilizer treatment	
	AML (m)	MAI (m/yr)	AML (m)	MAI (m/yr)
13	17.77		10.65	
		1.57		2.99
14	19.34		13.64	
		4.34		1.69
15	23.68		15.33	
Average		2.96		2.34

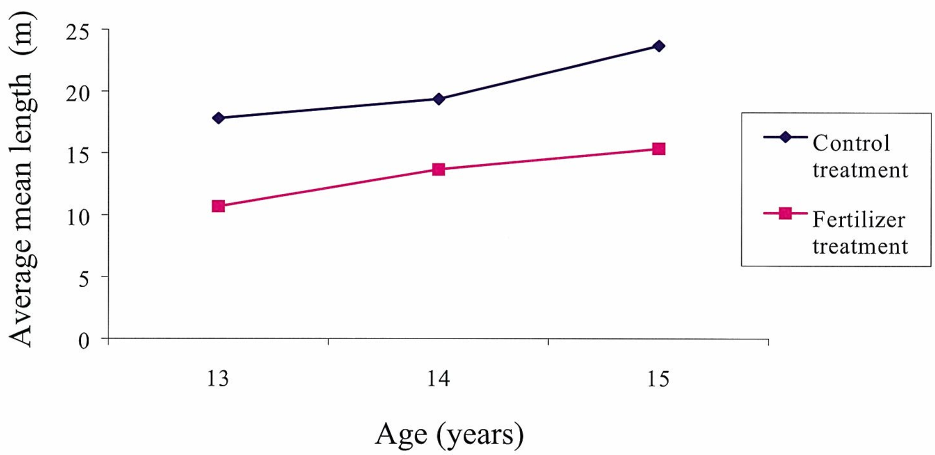

Figure 6. Average mean length of 13-15 years old *C. longisetus* in *Azadirachta excelsa* plantation

older rattan, 2.34 m at the age of 13-15 years, was lower than that of the younger ones, *i.e.*, 4.61 m at the age of 8-10 years (Kuldilok, 2000).

The growth of 13-, 14-, and 15-year-old *C. latifolius* had the average length of 25.25, 26.98 and 29.52 m, respectively with MAI of 2.16 m compared with 29.81, 34.56 and 35.36 m average length and MAI of 2.77 m of those in fertilizer plots (Table 6 and Figure 7). The MAI in both cases was lower than those of the younger ones, *i.e.*, 5.48 m of 8- to 10-year-old rattan. The results of this investigation confirm that harvesting age should be between 10-13 years.

Table 6. Average mean length (AML) and mean annual increment (MAI) of 13-15-year-old *Calamus latifolius* in *Azadirachta excelsa* plantation

Age	Control		Fertilizer treatment	
	AML (m)	MAI (m/yr)	AML (m)	MAI (m/yr)
13	25.21		29.81	
		1.77		4.75
14	26.98		34.56	
		2.54		0.78
15	29.52		35.34	
Average		2.16		2.77

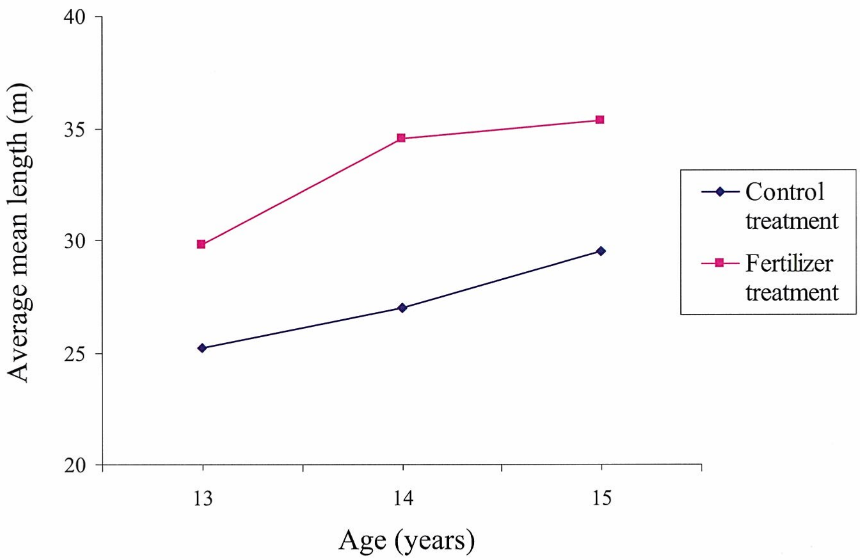

Figure 7. Average mean length of 13-15-year-old *Calamus latifolius* in *Azadirachta excelsa* plantation.

The results from the study indicated that *C. longisetus* in control plots had better cane increment than that growing in fertilizer plots. This was due to a bias of plot allocation as rattan in control plots had more canes in the cluster than those in fertilizer plots. The cluster size had some influence on mean annual increment. Thus, cluster size should be taken into consideration in sample plot allocation. It was obvious from this experiment that cluster size had no effect on the length of the longest leading cane in the cluster. All the large clusters composing more than 5 canes in the cluster also had the longest leading cane, but not different from those smaller cluster of 1 or 2 canes. This was why larger cluster size had higher mean annual increment. The cluster size should be one of the important criteria for genetic selection of rattan as well as for the management of rattan for good production. *C. latifolius* in the fertilizer plots had higher increment than those in the control plots.

The number of shoots and suckers of the cluster in control plots is presented in Tables 7 and 8. It was found that *C. longisetus* at the age of 13, 14 and 15 years had an average of 2.25, 2.40 and 2.42 canes per cluster, respectively, while the average number of suckers was 6.65, 5.35 and 5.45 suckers per cluster. These figures were much higher than those in fertilizer plots with 1.37, 1.66 and 1.61 canes per cluster and 4.98, 4.49 and 4.29 suckers per cluster, respectively.

Table 7. Number of canes and suckers of 13-15-year-old *Calamus longisetus* in *Azadirachta excelsa* plantation

Age	Control treatment		Fertilizer treatment	
(year)	cane/cluster	sucker/cluster	cane/cluster	sucker/cluster
13	2.25	6.65	1.37	4.98
14	2.40	5.35	1.66	4.49
15	2.42	5.54	1.61	4.29

Table 8. Number of canes and suckers of 13-15-year-old *Calamus latifolius* in *Azadirachta excelsa* plantation

Age	Control treatment		Fertilizer treatment	
(year)	cane/cluster	sucker/cluster	cane/cluster	sucker/cluster
13	3.68	7.70	4.07	8.23
14	3.68	7.91	4.20	9.05
15	3.49	8.74	4.00	11.00

C. latifolius in fertilizer plots at the age of 13, 14 and 15 years had an average of 3.68, 3,68 and 3.49 canes per cluster with 7.70, 7.91 and 8.74 suckers per cluster, respectively.

The number of suckers in the control plots was less than that in fertilizer plots. At the same age, the rattan in fertilizer plots had an average of 4.07, 4.20 and 4.00 canes per cluster with 8.23, 9.05 and 11.00 suckers per cluster, respectively at the age of 13, 14 and 15 years. The number of canes and suckers per cluster of *C. latifolius* was higher than those of *C. longisetus.*

The results of the study in Malaysia revealed that *C. manna*, the solitary rattan, growing in rubber plantation at 8 years old had the average cane length of 9.98 m, some in the gentle slope, with lower survival rate but better growth, could reach 14.21 m.

Mohamad (1992) found that *C. manan* planted in rubber plantation had very good growth, *i.e.*, 15.27 m long when harvested at 7 years old. Noor *et al* (1989) found that rattan planted in natural forest had very slow growth with canes length ranging from 0.05 to 23.51 m with 3.14 m in average. It was also found that 52% of the canes were shorter than 1 m. Baharudin and Ah (1982) also found that *C. manan* planted in conservation area at 13 years old had survival less than 50% and 73% of the canes were shorter than 1 m. There were only two canes growing under the light gap of the trees canopy that had canes longer than 15 m.

Productivity

Tables 9 and 10 present mortality rates of *C. longisetus* and *C. latifolius* at different ages. It was found that *C. longisetus* at 13 years old had the largest number of dead canes (32.79%), but mortality rates of these two species at 14 and 15 years old were not different.

The average cane diameter of *C. longisetus* was 3.5 cm with 55% commercial length compared with 3.4 cm and 50% of *C. latifolius.* The canes climbing up to the trees were longer than those spreading on the ground. However, slower growing canes on the ground had more dried-out leaves and leaf sheath with longer useable part. Generally speaking, older canes are longer with longer commercial length.

Table 9. Mortality rate of 13-15-year-old *Calamus longisetus*

Age (year)	Control (%)		Fertilizer treatment (%)		Average
	Plot I	Plot II	Plot III	Plot IV	
13	33.33	19.57	41.30	36.96	32.79
14	7.14	7.32	-	-	3.62
15	2.44	2.56	15.63	2.50	5.78

Table 10. Mortality rate of 13-15-year-old *Calamus latifolius*

Age (year)	Control (%)		Fertilizer treatment (%)		Average
	Plot I	Plot II	Plot III	Plot IV	
13	6.02	5.94	12.61	-	6.14
14	7.14	5.64	5.36	2.47	5.23
15	6.33	10.00	8.85	8.75	8.48

It was found from this study that *C. longisetus* had 89% survival with the total productivity, at 13, 14 and 15 years old, of 1,028.65, 1,113.87 and 1,357.35 m per rai, compared with 1,809.88, 1,963.83 and 2,074.64 m per rai of *C. latifolius*.

With the same age category, total commercial length of *C. longisetus* was 565.76, 612.63 and 746.54 m per rai, respectively, compared with 1,085.93, 1,178.30 and 1,244.78 m per rai of *C. latifolius* (Table 11 and Figure 8). In comparison, Kuldilok (2000) found the total commercial length of *C. longisetus* at the age of 8, 9 and 10 years was 78.00, 189.01 and 456.53 m per rai, respectively, and 212.79, 466.08 and 724.20 m per rai of *C. latifolius.*

CONCLUSIONS AND RECOMMENDATIONS

1. The growth studies using 4.5 m as a basis for length classification showed that *C. longisetus* at the age of 13, 14 and 15 years in control plots had 51.43% in length class1, 48.21% in length class 1, and 35.25% in length class 2, respectively, and 48.21%, 53.56% and 38.46% of canes in class 1 in case of fertilizer plots. *C. latifolius* in control plots had 57.56%, 46.82% and 35.85% of canes in class 1, and 49.44%, 44.02% and 37.14% of canes in class 1 for those in fertilizer plots.

Table 11. Productivity of *Calamus longisetus* and *Calamus latifolius* in *Azadirachta excelsa* plantation

Age (year)	C. *longisetus*			C. *latifolius*		
	Survival (%)	Length (m/rai)	Tradable (m/rai)	Survival (%)	Length (m/rai)	Tradable (m/rai)
13	89	1,028.65	565.76	91	1,809.88	1,085.93
14	89	1,113.87	612.63	91	1,963.83	1,178.30
15	89	1,357.35	746.54	91	2,074.64	1,244.78

Note: - Commercial length > 8 m
- Percentage of commercial length of C. *longisetus* is 55% and C. *latifolius* is 60%

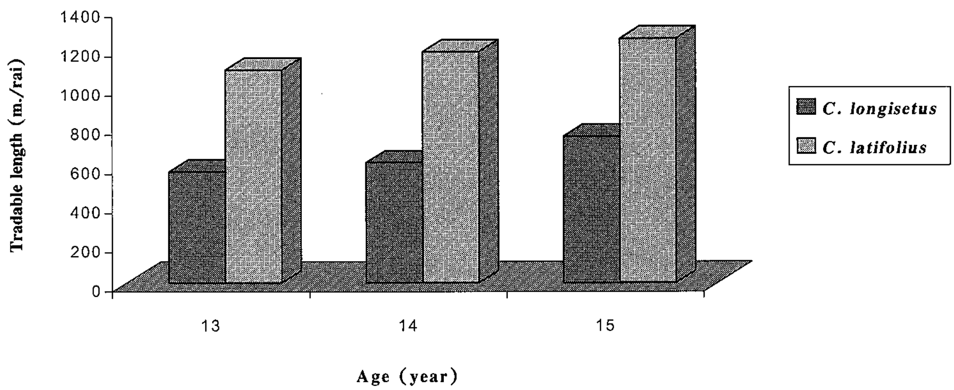

Figure 8. Commercial length of canes of *Calamus longisetus* and *C. latifolius* in *Azadirachta excelsa* plantation.

2. The average cane length of *C. longisetus* at age 13, 14 and 15 years old in control plots were 17.77, 19.34 and 23.68 m, respectively with MAI of 2.96 m per year compared with 10.65, 13.64 and 15.38 m, and 2.34 m per year MAI of those in fertilizer plots. *C. latifolius* in control plots at 13, 14 and 15 years old had average cane growth of 25.21, 26.98 and 29.52 m with 2.16 m per year MAI, compared with 29.81, 34.56 and 35.34 m and 2.77 m per year MAI for those in fertilizer plots.

3. *C. longisetus* and *C. latifolius* had 89% and 91% survival with 55% and 60% commercial part, respectively. The commercial productivity of *C. longisetus* at 13, 14 and 15 years old was 565.76, 612.63 and 746.54 m per rai, respectively, and 1,085.93, 1,178.30 and 1,244.78 m per rai in case of *C. latifolius.*

4. *C. latifolius* at all age classes had better growth performance than *C. longisetus* when intercropped in *Azadirachta excelsa* plantation.

5. Although *C. latifolius* is not native in southern part of the country, it can grow better than the native *C. longisetus* in southern conditions. Thus, it is recommended that *C. latifolius* be planted for commercial purposes in the south. The cane *C. latifolius* is also of superior quality.

6. The commercial value of canes from these two species is 6-8 Baht per meter at local market and 12-15 Baht per meter in Bangkok. The returns of *C. longisetus* at 13, 14 and 15 years old is expected to be 4,000 – 7,000, 4,300 – 8,300 and 5,200 – 10,000 Baht per rai, respectively, and 2,600 – 14,700, 8,200 – 15,900 and 8,700 to 16,800 Baht per rai in case of *C. latifolius.*

7. With proper management, these two rattan species can be commercially harvested since the canes are 10 years old with annual production of 100 m per rai or 700 – 1,350 Baht. These species could be recommended for commercial planting in tree plantation as an intercropping.

8. The rattans intercropped in tree plantation grow better than those planted under natural forest, except in the degraded area with suitable light conditions.

9. Large-scale commercial planting of rattan must be promoted to meet great demand for furniture industry and OTOP project country-wide the production of which are dependent on the import of rattan raw materials.

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Study on Planting and Management of *Calamus caesius* for Cane Production at Narathiwat Province

by

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Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

Royal Forest Department

Thailand

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Study on Planting and Management of *Calamus caesius* for Cane Production at Narathiwat Province

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The study on planting and management of Calamus caesius for cane production was carried out in natural forests in Narathiwat province during 2001 to 2004. Three experimental plots were established from which the data on growth and number of shoots were collected. An average length of 5-year-old C. caesius growing in swampy area with temporary flood was 368.08 cm compared with 71.17 cm of those in degraded area along hill slope. The 18-year-old C. caesius planted in abandoned deforested area had the cane of 404.14 cm long in average. Results from the experiment on harvesting system showed that 1–2 canes/clump harvesting resulted in induction of growth performance and the increase in the number of new shoots, while harvesting of 3 canes per clump caused a decrease in growth and number of new shoots during the first year, but increase in the following years.

INTRODUCTION

Rattan, plant species with the longest stem in the world, belongs to family of Palme. Some canes are found to be longer than 450 m (Pitta, 1981). For a long time that utilization of rattan is closely related to the way of life of rural people who use rattan as raw material for furniture making and fastening stuffs. In natural forest, rattan has rapidly been depleted due to over exploitation resulting in the shortage of rattan raw material that relies on the import from neighboring countries. The first rattan plantation in Thailand was established in 1968 in small area at Istear district, Narathiwat province, followed by additional planting in

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natural forest which increased the area of rattan plantation to over 10,000 rai (Chanatip and Somboon, 2002). However, it was found that those additional rattans planted in the natural forest grew very slowly. An appropriate technique and management including the selection of potential species suitable for each particular site should be required. *Calamus caesius*, a small cane rattan with good quality and fine golden shiny skin, has high potential for shoot production and is a promising species to be planted as substitute for the shortage of raw rattan materials in Thailand.

MATERIAL AND METHODS

Growth Performance

Permanent plots, 50 x 50 m, were established in 3 plantations of *C. caesius* plantations, one in peat swamp forest at Su Ngai Padi district (5 years old) and the others two in tropical rain forest (5-year-old plot at Little House in the Big Forest Plantation Project and the 18-year-old plot at Ban Toh Moh), Sukirin district, Narathiwat province. Each plot was divided into 25 sub-plots of 10 x 10 m Each clump was numbered and location marked for growth observation.

Effects of Harvesting on Growth and Number of New Shoots

1. Observation on the number of canes per clump was taken place at Ban Toh Moh plantation (18 years old plantation), Sukirin district, Narathiwat province. Rattan clumps were classified into 6 classes according to number of canes per clump, *i.e.*, <10, 10-20, 21-30, 31-40, 41-50, and >50 canes per clump. Ten clumps from each class were selected after which only 3 classes with 13-19, 20-26 and 27-33 canes per clump were selected for the study on harvesting practices.

2. Six clumps were randomly selected and divided into 2 groups of 3 clumps each. Mature canes of the first 3 clumps were harvested and the shoots shorter than 1 m were numbered and measured, while the other 3 clumps were left un-harvested. In the class with 13-19 canes per clump, 1 cane was harvested while 2 and 3 canes per clump were removed from the clumps with 20-26 and 27-33 canes, respectively.

3. The diameter was measured at every 1 m of the cane and the green and dry weight observed. Moisture content was determined from 2-m section of

the cane oven dried at 80 °C for 48 hours. New shoots were numbered and the growth of new shoots was measured every 3 months.

Durability of Rattan Cane

The study on durability of 3 rattan species: *C. caesius* Blume, *Calamus laevigatus* Mart., and *Korthalsia laciniosa* (Griff.) Mart) was conducted using the top, middle, and bottom parts of 1 m long. The samples were hung under the sunlight in open conditions at Pikulthong Research Station, Conservation Zone under the Royal Pikulthong Development and Study Project, Su Ngai Kolok district, Narathiwat province. Deterioration of canes of each species was regularly observed.

RESULTS AND DICUSSION

Growth of *Calamus caesius*

Rattan in Peat Swamp Forest

For the 5-year-old *C. caesius* growing in peat swamp forest, 229 clumps (575 canes) were found in the area of 50 x 50 m or 10.91 clumps per m^2 with an average of 2.52 ± 1.61 canes/clump. An average length of the longest cane from all clumps was 368.08 cm while the total average was 188.71 cm, and the average diameter at 10 cm above ground level was 0.85 cm. After 1 year, the length of the longest cane had increased by 155.10 cm making the total average length to be 523.18 cm. However, only 36.18 cm increase in length was found in the second year, and the total average was 559.36 cm. Moreover, it was found that 46 canes of 5 to 6 years old had died, while mortality rate increased to 89 canes among those of 6 to 7 years old. The cause of mortality might be flood, pests and diseases. It was also found that the diameter of the cane decreased gradually when rattan had become older, *i.e.*, average diameter of 1.06, 0.89 and 0.84 cm, respectively at the age of 5, 6 and 7 years.

Rattan in Tropical Rain Forest

Rattan at the Little House in the Big Forest Plantation

Approximately, 4.8 % of 5-year-old *C. caesius* growing at 2 x 4 m spacing started sprouting 1-2 shoots. Original clump had an average diameter of

1.01 cm (at 10 cm above ground level) and average height of 71.17 cm. After 16 months, it was found that the diameter of *C. caesius* was not much changed while the average height increased to 79.25 cm and the average length was 152.8 cm. Each clump initiated 1-3 shoots making the proportion of clump with new shoot up to 47.05%. After 1 year or at 7 years old, an average length increased 61.82 cm and average length was 210.69 cm. Some clump (about 60.52% of the clumps that produced shoot) produced up to 5 shoots.

It can be noticed that *C. caesius* at 5-7 years old provided an average height increment of 61.82–79.25 cm. However, the growth of *C. caesius* was very low as an average height of 5-year-old rattan was only 71.17 cm, or 14.23 cm/year during the first 5 years. Since this plantation was established without fertilizer, it is recommended that fertilizer application in *C. caesius* plantation be urgently taken place.

Rattan Plantation at Ban Toh Moh Plantation

There were 65 clumps of 18-year-old *C. caesius* in the area of 50 x 50 m^2 (38.46 m^2/clump). Approximately, 67.9 % of all clumps produced 1-69 shoots of 14-1,886 cm long, the average length of all clumps being 404.14 cm. Based on the data, it can be concluded that the commercial length of *C. caesius* was about 21–43 m (average 28.67 ± 10.64 m). This length did not include about 30% of un-useable length. Thus, total length of rattan ranged from 27.3 to 55.9 m with an average of 37.27 ± 13.86 m. There was a great variation in growth as this plantation was established in supplement to the naturally grown ones. Therefore, plantation management needs particular knowledge as *C. caesius* will not grow well under improper conditions.

Effects of Harvesting on Shoot Growth

The results of the observation on 77 clumps of 18-year-old *C. caesius* plantation at Ban Toh Moh, Narathiwat province revealed that each clump contained 5–158 canes (28.47±30.49 canes/clump). These clumps were classified in groups of 5-9, 10-20, 21-30, 31-40, 41-50, 51-80, 81- 110, 111- 140, and 141-170 canes/clump which accounted for 20, 34, 19, 8, 3, 16, 11, 1, 1, and 3 %, respectively. Great variation in number of canes per clump implied that improper management would result in low cane production. Suitable management practices would significantly increase the number of canes and the value of plantation, *e.g.*

158 canes/clump and 3,160 Baht/clump compared with those 5 canes and 100 Baht/clump under traditional management.

Effects of Harvesting on the Number of New Shoots

The observation was made on 75 days after harvesting. Results showed that the clump consisted of 13-19 canes, with 1 cane harvested, produced only 1 shoot from 3 replicated clumps (average 0.33 shoot/clump) while non-harvested clumps produced 1.67 shoots/clump. In contrary, the clumps that contained 20-26 canes with 2 harvested canes produced an average of 1.67 shoots/clump compared with only 0.33 shoots/clump of the non-harvested ones. Moreover, the clump that contained 27-33 canes with 3 canes harvested produced only 1 shoot/clump, similar result being found in the non-harvested clumps.

The second observation was taken place 120 days after harvesting. The clumps with 1-2 canes harvested produced more shoots than those without harvesting while the clump with 3 canes harvested even produced fewer shoots than those without harvesting. The same trend was found 195 days after harvesting as that of the second observation (120 days). Moreover, the results of the forth and fifth observation, *i.e.*, 315 and 380 days after harvesting, showed that all harvested clumps showed double amount of shoot production. This can be clearly described that harvesting of some mature canes would help enhance the productivity of the plantation. It was possible that old canes might consume more nutrients than what it produced insufficient for supporting new shoots. Thus, after some canes were removed there was enough food to support the new shoots. On the other hand, removal of some canes might disturbed the remaining plants and weaken shooting capacity. The rate of shoot production is presented in Figure 1.

Effects of Harvesting on the Length of *C. caesius* Cane

After 1 year, the clumps with 1 and 2 canes harvested had the average shoot length of 587 and 518 cm, respectively, compared with 424 and 302 cm of those non-harvested. However, the average length of shoot from the clumps with 3 canes harvested was less than average length of those non-harvested (Figures 2 and 3). It was noticed that the number of shoots in case of 3 canes harvested was more than those with 1 or 2 canes harvested. Thus, the total length of shoots of 3-cane-harvested clumps was more than those of the non-harvested. It could be concluded that harvesting of 1, 2 and 3 canes per clump increased the total length of *C. caesius* by 2.67, 3.70 and 1.35 folds, respectively.

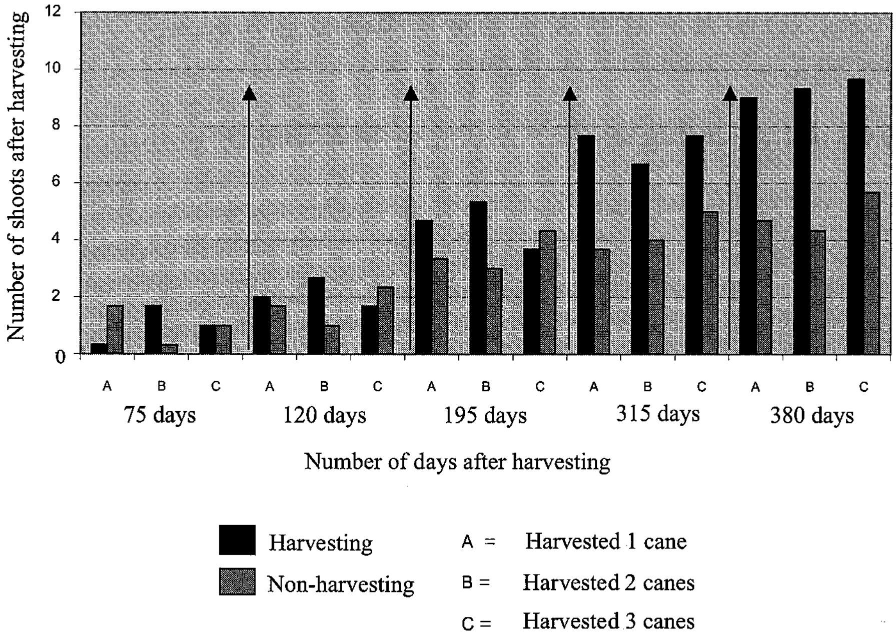

Figure 1. Effects of harvesting on number of shoots.

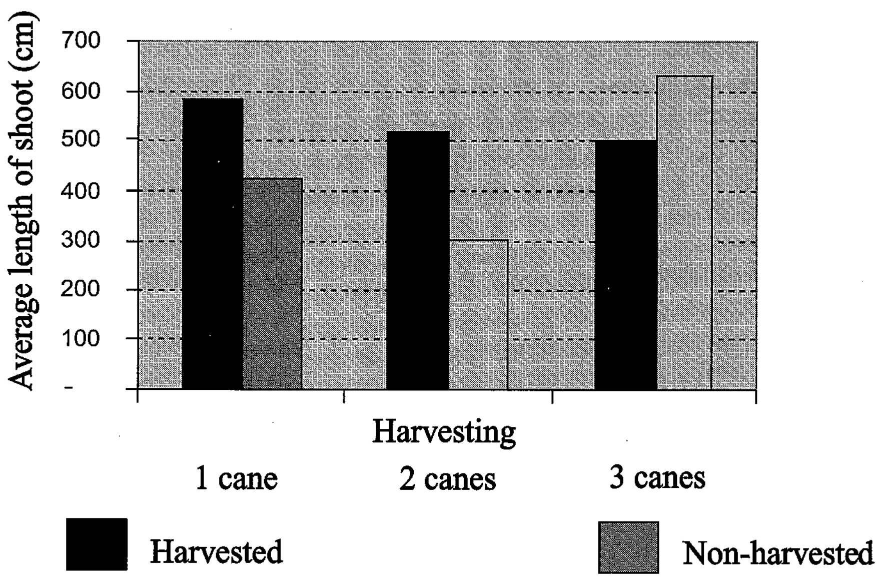

Figure 2. Average shoot growth, 1 year after harvesting.

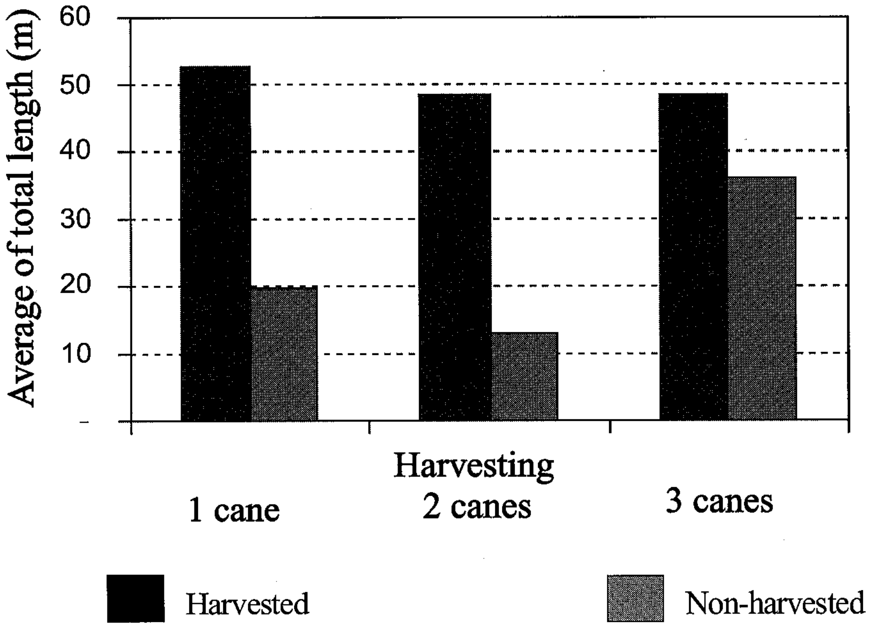

Figure 3. Average shoot length, 1 year after harvesting.

Within one year, young shoots of 18-year-old clump could reach the length of 302-604 cm, compared with 16.44 cm of those developed from seedling. This implied that proper harvesting and management *of C. caesius* plantation could increase cane production for sustainable use.

Some Characteristics of *C. caesius*

It was found that fresh weight of commercial length of *C. caesius* ranged from 0.6 to 2.8 kg/cane with an average of 1.41 ± 0.90 kg/cane, dried weight being from 0.28 to 1.28 kg/cane (0.65 kg/cane on average). Moisture content of the cane was 45.78 % and average commercial length was 28.67 ± 10.60 m. The results of durability test of 3 rattan species (*C. caesius*, *C. laevigatus*, and *Korthalsia laciniosa*) for 1 year showed that the highest durability was found in *Korthalsia laciniosa* followed by *C. laevigatus* and *C. caesius.* It was also noticed that the base part of the cane of each rattan species was more durable than other parts.

CONCLUSIONS

1. Growth of *Calamus caesius* growing in peat swamp with occasionally flooded is better than those in degraded area.

2. Harvesting of 1-2 canes per clump can increase the number of new shoots and induce the shoots to grow better while harvesting of 3 canes per clump will cause some effects on the number of new shoots during the first year, but will be improved afterwards.

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Planting and Management of Rattan for Shoot Production

by

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Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

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Planting and Management of Rattan for Shoot Production

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INTRODUCTION

Rattan shoots are favorite food of the people in the northeastern and some northern part of Thailand for long time since the old day. This behavior together with cane utilization for local handicrafts, utensil production and other kind of local utilization are the factors contributing to the depletion of rattan resources in natural forest.

The people in the northeastern part of the country have succeeded in planting rattan for shoot production for their own consumption and also for commercial purpose since late 1980's. Since then, the establishment of rattan plantation has become very popular that contributes a great deal to the income of local people. This practice provides more return than growing many other agricultural crops.

At present, general techniques for planting are quite well established by the knowledge of local people together with technical assistance and various supports from the Royal Forest Department. In spite of these situations, there are still a room for further improvement on various aspects to increase shoot production and product development.

There are three rattan species grown as a plantation for shoot production, *i.e., Calamus viminalis, C. siamensis* and *C. tenuis* among which *C. viminalis* is the most popular one. The *C. viminalis* plantation is normally established in the open area on the upper terrain site. This rattan species is preferable due to the taste of the shoot and better shoot production with rather large shoot even planted in open area and dry conditions on the upper terrain. It is one of the drought-tolerant species.

The other two species have been planted in smaller extent in particular

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area. The shoots of *C. siamensis* taste bitterer, while the other two species have not only shoots good as food but also good cane properties suitable for handicrafts and other uses. For shoot production, one farmer can manage only about 2 rai of plantation, as it is labor intensive for shoot harvesting. The improvement of productivity of the plantation can contribute substantial income to the farmers. There are a number of researches undertaken by the Royal Forest Department for improvement of shoot productivity and cost reduction. However, there remains the research needs for sustainable management of rattan on a sustainable basis. The plantation is typically established in an open area since it is more practical for the farmers, but it may not be environmentally sound in long term. The current production emphasizes only on shoot production. The establishment and management of rattan plantation in the future should be focused on multi-purpose production and environmentally friendly practices. The shoot and cane production should be combined in order to open more opportunities for local people to generate income from handicrafts beside food production under sustainable basis.

MATERIAL AND METHODS

Experiment I: Manure and Chemical Fertilizer Application in Shoot Production of *Calamus viminalis*

The experiment was conducted in 4-year-old and 3-rai rattan plantations belonging to 3 local farmers in Phupan district, Sakon Nakhon province as follows.

a.) Mr. Somwang Pongntha, Kam Perm village, Tambon Kokphu.

b.) Mr. Chalermchai Simukda, Kud Had village, Tambon Kudbat.

c.) Mrs. Wantong Sannarong, Nangterng village, Tambon Kokphu.

These plantations have been established with 3.0 x 1.5 m spacing under open conditions and already been at shoot production stage. The experimental plots covered 10 rattan clusters row plots with 3 clusters as a buffer between plots in the row. There were two treatment plots and a control plot in each experimental block of 54 x 3 m (Figure 1). The experiment was completely randomized block design with 4 blocks of replications.

Tr 1	=	Treatment 1	manure application, 15 kg/cluster once a year in the hole between each cluster and covered with soil, and only half dose at the end of the plots.
Tr 2	=	Treatment 2	chemical fertilizer (25-7-7), 100 grams per cluster, two times a year in early and mid rainy season.
Tr 3	=	Control	

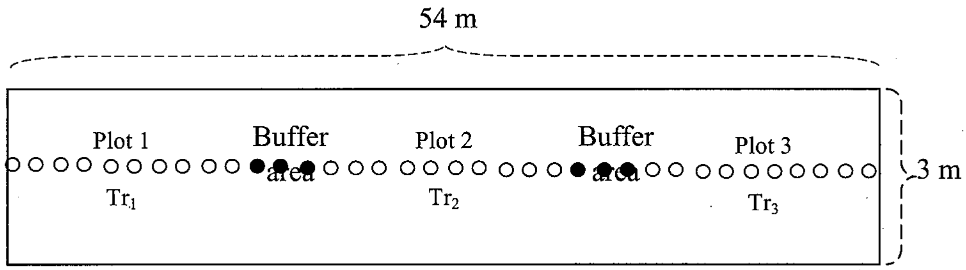

Figure 1. The experimental block of 54 x 3 m.

The data on number of shoots produced from every cluster were collected for the period of 18 months, for the analysis of variance to determine the effect of various treatments on shoot production.

Experiment II: Watering and Manure Application in Shoot Production of *Calamus viminalis*

The experiment was conducted in 5-year-old rattan plantation with 3 x 1 m spacing at Sakon Nakhon Nonwood Forest Products Research Center.

The experimental plot was two rows of 5 clusters plot with 4 clusters in the row as buffer between plots. There were 10 clusters in each experimental plot with 5 on each of 2 rows plot. There were three treatment plots and the control plot in each block of 32 x 3 m. The experiment was completely randomized block design with 3 blocks as the replications (Figure 2).

Tr 1 = Treatment 1 manuring once a year plus 60 mm weekly watering.

Tr 2 = Treatment 2 manuring once a year plus 30 mm twice a week watering.

Tr 3 = Treatment 3 manuring once a year.

Tr 4 = Control

Manuring was done by the application of 15 kg manure (cow dung) in the hole between rattan clusters.

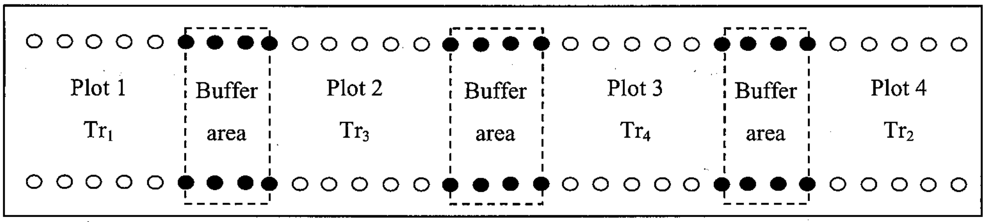

Figure 2. The experimental block of 32 x 3 m.

The number of shoots produced for the period of 18 months from October was recorded. Fresh weight of consumable part, obtained by peeling off all leaf sheaths to get only edible portion and weight from all treatments and control were also observed. All the data were used for analysis of variance to determine the treatment effects.

Experiment III: Spacing Trial of *Calamus viminalis* and *Calamus siamensis* for Shoot Production under Tree Plantation

The study was taken place at Sakon Nakhon Nonwood Forest Products Research Center in *Butea frondosa* and *Combretum quadrangulare* old plantations (6 x 6 m spacing) previously used for lac production.

The experiment was split plot design where 2 rattan species were allocated as the main plots of 6 x 12 m block with two rattan planting spaces, 1 x 1 m and 1 x 0.5 m, as sub plots in each main plot. There were 4 replications in the experiment as shown in Figure 3.

The data on growth and number of shoots were recorded on 12^{th} and 18^{th} month after planting. The number of 8 clusters from each treatment that produced consumable shoot was randomly selected for data collection, and weight of consumable part of the largest shoot in each selected cluster was recorded.

Experiment IV: Establishment and Management of *Calamus tenuis* and *Calamus siamensis* Plantations for Combined Shoot and Cane Production

The experiment was conducted at Sakon Nakhon Nonwood Forest Products Research Center in 20-year-old *Butea frondosa* and *Combretum* *quadrangulare* plantations with 6 x 6 m spacing. Two rattan species, *Calamus tenuis* and *Calamus siamensis,* were planted in two-row plot of 15 clusters in each row with the spacing of 1 x 1 m. These two plots of 14 x 1 m were allocated between tree rows with 1 m from tree rows on each side and 2 m between plots in the block. The experiment was completely randomized block design with 4 blocks as the replications as presented in Figure 4.

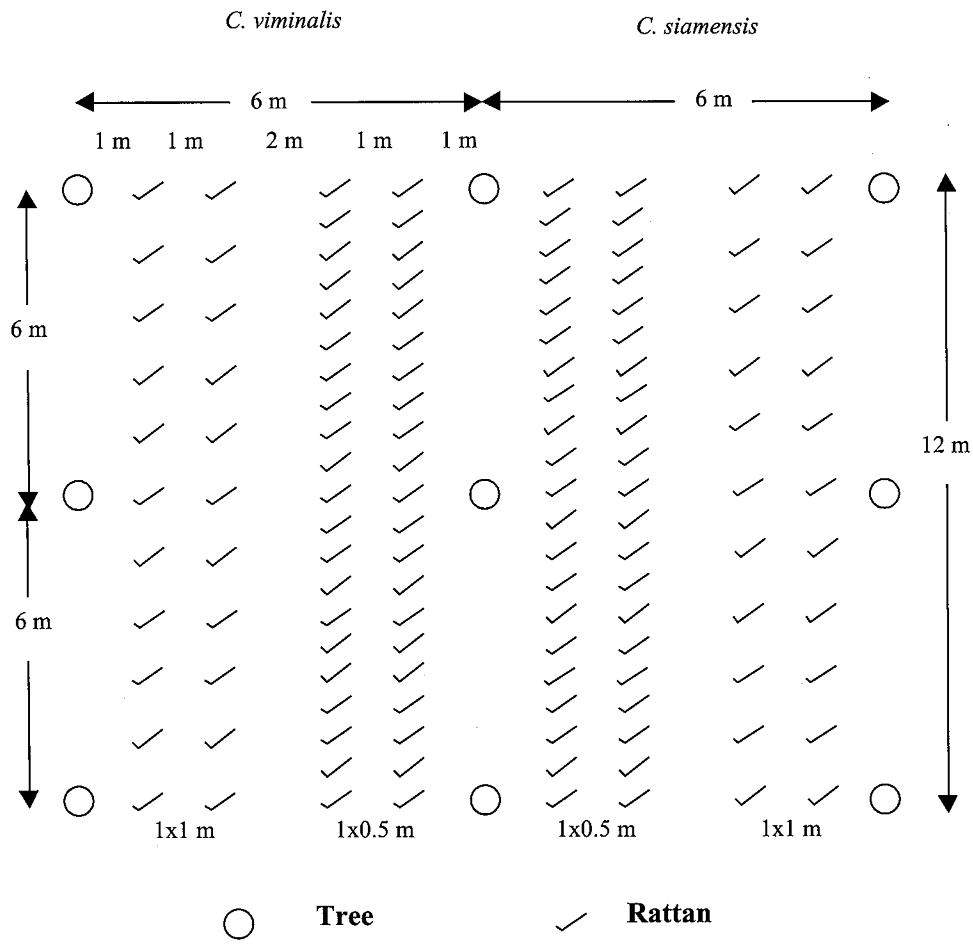

Figure 3. The experimental block of 12 x 12 m.

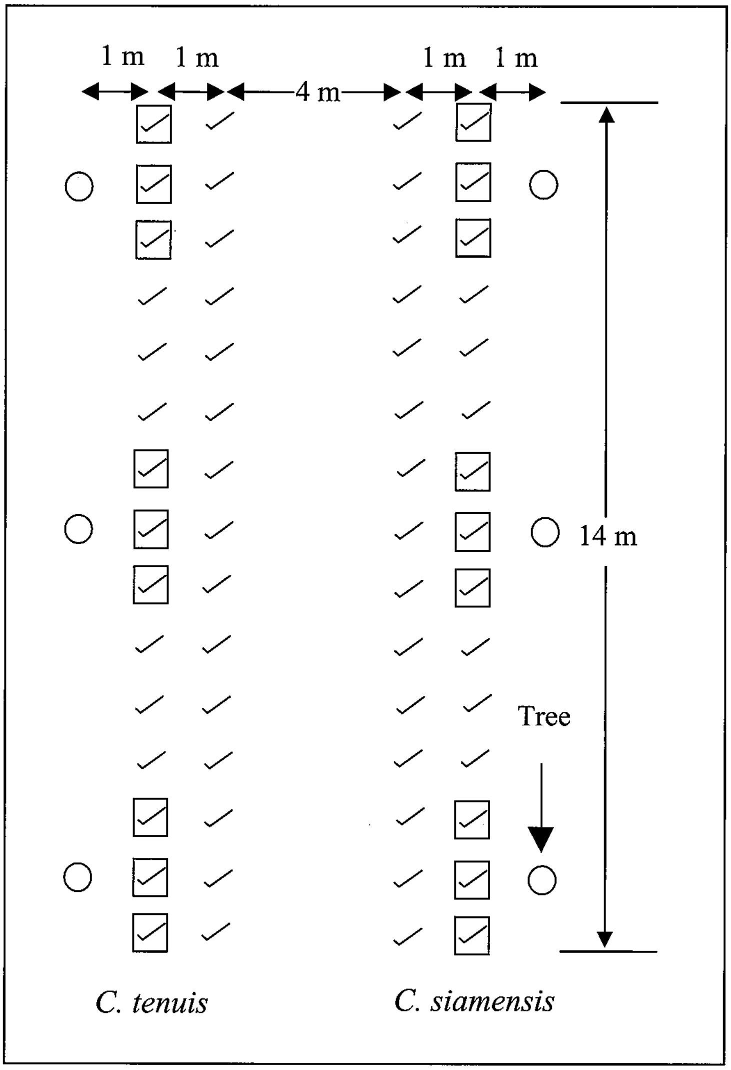

Figure 4. The experimental block of 6 x 14 m.

The combined management was done using 9 rattan clusters in the plot near the 3 tree trunks for shoot and cane production by leaving only one good cane from each of these clusters to develop for cane, and all other shoots in these clusters were harvested. All other clusters in the plots were managed for shoot production only.

The data on height growth or cane length and the number of shoots together with the weight of consumable part of the shoots were collected on 18th and 24th month after planting.

RESULTS AND DISCUSSION

Experiment I

The results of the experiment on the effects of manure and chemical fertilizer application on shoot production of *C. viminalis* revealed that, 4-year-old *C. viminalis* being manured once a year had the shoot production of 10.89 shoots/cluster. The productivity was significantly better than those with chemical fertilizer (25-7-7, 100 gm/cluster twice a year) which produced an average of 9.76 shoots/cluster, and average of 7.01 shoots/cluster in control. The results of these two treatments were also significantly better than that of control.

Experiment II

A 5-yaer-old *C. viminalis* at 5 years old treated with manure cum 60 mm watering once every week or 30 mm twice a week had better shoot production than those of sole manuring and control. There was no difference in shoot production among 2 methods of watering. The manuring alone also had better shoot production significantly better than the control. The result from this experiment also confirmed those in Part I that manuring gave better shoot production than the control.

The average shoot production at the end of the 18th month of Tr 1, Tr 2, Tr 3 and Tr 4 was 10.6, 10.9, 8.3 and 5.8 shoots/cluster, respectively, while the weight of consumable part of shoot was 40.0, 40.5, 36.0 and 28.5 gm/shoot. Tr 1 and Tr 2 were not different, but significantly better than all the others, among which Tr 2 was the best. Rattan under twice-a-week watering had larger shoots with more consumable part.

Experiment III

The result showed that *C. viminalis* and *C. siamensis* planted under tree plantation with two densities had good survival rate, *i.e.*, higher than 95%.

At 18 months after planting, average shoot production of *C. viminalis* at 1 x 1 m and 1 x 0.5 m planting spaces was 2.0 and 1.8 shoots/cluster, respectively, compared with 2.0 and 2.1 shoots/cluster of *C. siamensis*. At 1 x 1 m spacing, shoot production of both species was not statistically different. However, *C. siamensis* at 1 x 0.5 m spacing produced more shoot than *C. viminalis* with statistical difference in number of shoots.

The average consumable part per shoot of *C. viminalis* at 1 x 1 m and 1 x 0.5 m planting spaces was 21.9 and 16.4 gm/shoot, respectively, compared with 21.6 and 18.2 gm/shoot of *C. siamensis*. It was shown that at 1 x 1 m spacing the consumable part of the shoots of these two species was not statistically different, but at 1 x 0.5 m spacing *C. siamensis* produced larger shoot with more consumable part than *C. viminalis*. Moreover, shoots of both species at 1 x 0.5 m spacing were smaller with less consumable part than those produced at 1 x 1 m spacing.

Experiment IV

The results of the study on integrated management for shoot and cane production indicated that *C. tenuis* and *C. siamensis* had the average cane length of 1.47 m and 1.63 m within 1 year and 6 months after planting in tree plantation with no statistical difference. It was found that the average shoot production of *C. tenuis* and *C. siamensis* were 3.0 and 3.5 shoots/cluster respectively with statistical difference.

CONCLUSIONS AND RECOMMENDATIONS

1. Manuring of a 3-year-old *C. viminalis* plantation increase shoot production better than chemical fertilizer.

2. The application of manure once a year with 60 mm weekly watering during dry season in 5-year-old *C. viminalis* plantation can increase shoot production better than manuring without watering. The manuring and watering at the rate of 30 mm twice a week can also increase shoot production as well as shoot size and consumable part, while weekly watering at the rate of 60 mm can increase only shoot production.

3. At 1 x 1 m spacing, *C. viminalis* and *C. siamensis* produce the same number of shoots per cluster with the same amount of consumable part. At 1 x 0.5

m spacing, *C. siamensis* produce more shoot per cluster with more consumable part than those of *C. viminalis*. *C. siamensis* can be managed for better yield.

4. The results of the study on integrated management of *C. tenuis* and *C. siamensis* indicated that cane of both species grew at the same rate but *C. siamensis* produce more and larger shoot than *C. tenuis*.

5. From the production point of view, *C. siamensis* has more potential for planting under tree plantation which can be managed for both shoots and canes production. *C. siamensis* also has better cane properties. The taste of *C. siamensis* shoots is bitterer than that of *C. viminalis* shoots for which marketing of shoots must be taken into consideration in large-scale plantation and appropriate technology for shoot processing adopted. There is the possibility that the proper selection of suitable varieties of *C. siamensis* both good quality of canes and shoots. This success will open a future direction for the development of rattan plantation to combine both shoot and cane production under the tree plantation environment.

Since *C. siamensis* can tolerate drought period as good as *C. viminalis*, there is less limitation on site requirement for this species. The bitter taste may be overcome by using good varieties and proper processing techniques.

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Growth and Photosynthetic Performance of *Calamus viminalis*

by

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Royal Forest Department

Thailand

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Growth and Photosynthetic Performance of *Calamus viminalis*

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The objective of the study was to compare the growth of Calamus viminalsis seedlings grown under different light conditions as well as their growth and photosynthetic performance after planting in Combretum quardangulare plantation. Growth measurements of C. viminalis seedlings were taken place one year after growing under different light environments including 30 and 50% light intensities under nursery conditions and under the shade of Samanea saman (rain tree) trees. The results showed that the seedlings grown under 30 and 50% light intensities had significantly greater (p <0.01) height and diameter growth as well as total dry weight compared to those under S. saman shade. Particularly, the latter had only 50% of the total dry weight of the other two groups, probably due to their deep shade environments (only 15-20% of full sunlight) and/or their leaves covered by lac.

Eighteen and twenty four months after planting in Combretum quadrangulare plantation, C. viminalis grown under 30 and 50% light intensities showed greater growth performance, indicating its ability to adapt to shade environment in Combretum quadrangulare plantation with 30% of full sunlight. In the long term, however, this rattan species growing under rain tree tended to adapt well even though it had lower growth rate before planting in the field. Furthermore, photosynthetic performance of all the three groups was similar in the wet season but slightly different in their responses to seasonal drought during the dry season. C. viminalis growing under rain tree was able to maintain higher leaf photosynthetic activity in the dry season where water availability became limited, while that from seedlings under 30% light intensity was able to minimize water losses through leaf

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transpiration under such stress condition, resulting in greater water use efficiency. Further research on physiological processes contributing to rattan growth as well as genetic improvement is, therefore, recommended for sustainable management of C. viminalis plantation.

INTRODUCTION

Calamus viminalis (Waai Dong) is one of the most promising rattan species widely planted for commercial shoot production in northeastern part of Thailand. Its natural distribution has been reported in Malaysia, Indonesia, India, Bangladesh, Myanmar, Vietnam and China. In Thailand, it is often found in mixed deciduous, dry dipterocarp and dry evergreen forests all over northeastern region. It can grow on a variety of soil, ranging from lateritic to podzolic soil with loamy to sandy texture (Khemnark and Sombun, 2002).

In silvicultural practices, light is one of the most important factors that limit rattan growth depending on species. Rattan species can be classified into three types according to light environments for optimum growth: (1) tolerant or shade demanding species, growing well under less than 40% light intensity; (2) moderate light demanding species, growing best at 40-70% light intensity; and (3) light demanding species, requiring more than 75% for optimum growth. For instance, *C. simplicifolius* is likely to grow well under less than 40% light intensity, while *C. caesius* is the light demanding species (Khemnark and Sombun, 2002). For *C. viminalis*, local farmers generally plant this rattan species in an open area like other agricultural crops but, occasionally intercropped with other forest or fruit trees. Recently, more attention has been given to intercropping with trees as it can utilize planting area more efficiently and also improve environmental conditions for sustainable production. However, little is known about appropriate light intensity for optimum growth of *C. viminalis* as well as physiological processes associated with its growth under different light regimes. Photosynthetic capacity of plants growing in full sunlight is generally higher compared to those grown under lower light intensity (Björkman, 1981; Royampaeng, 2002), thereby increasing growth as photosynthesis provides the material needed for growth.

The objective of the study was to compare growth of *C. viminalis* seedlings grown under different light conditions. Moreover, variation in their growth and photosynthetic performance after planting in *Combretum quardangulare* plantation was also observed.

MATERIAL AND METHODS

Seedling Preparation and Growth Measurements

The study was taken place at the Non-wood Forest Products Experimental Station, Sakon Nakhon province, in June 2001. Seedlings of *C. viminalis* raised in black plastic bags were treated under the following light environments (Figure 1).

(a) Rattan seedlings under *Samanea saman* shade trees

(b) Rattan seedlings under nursery conditions

Figure 1. *Calamus viminalis* seedlings under different light environments.

- **Group I**- 15-20% light intensity under *Samanea saman* shade trees, which were planted mainly for lac culture;
- **Group II**- 30% light intensity under nursery conditions; and
- **Group III**- 50% light intensity under nursery conditions.

One hundred healthy seedlings were randomly selected from each treatment after one year and measurements of total height and diameter at root collar were undertaken. To determine the total leaf area, number of leaflets for each seedling sample was counted and leaf area was measured on ten seedlings and five compound leaves each, using the CI-202 Portable Leaf Area Meter (CID Inc., Canada). Subsequently, all seedling samples were dried at 70°C for two days until the weight remained constant and then re-weighed.

In addition, 80 healthy seedlings from each group were selected and planted in *Combretum quardangulare* plantation (6 x 6m spacing) at the onset of the wet season in June 2002. Seedlings of each group were planted systematically in 2 rows between tree rows with 1 m apart from each tree row and 1 m spacing between the rattan seedlings (Figure 2).

Growth Measurements after Planting in *C. quardangulare* Plantation

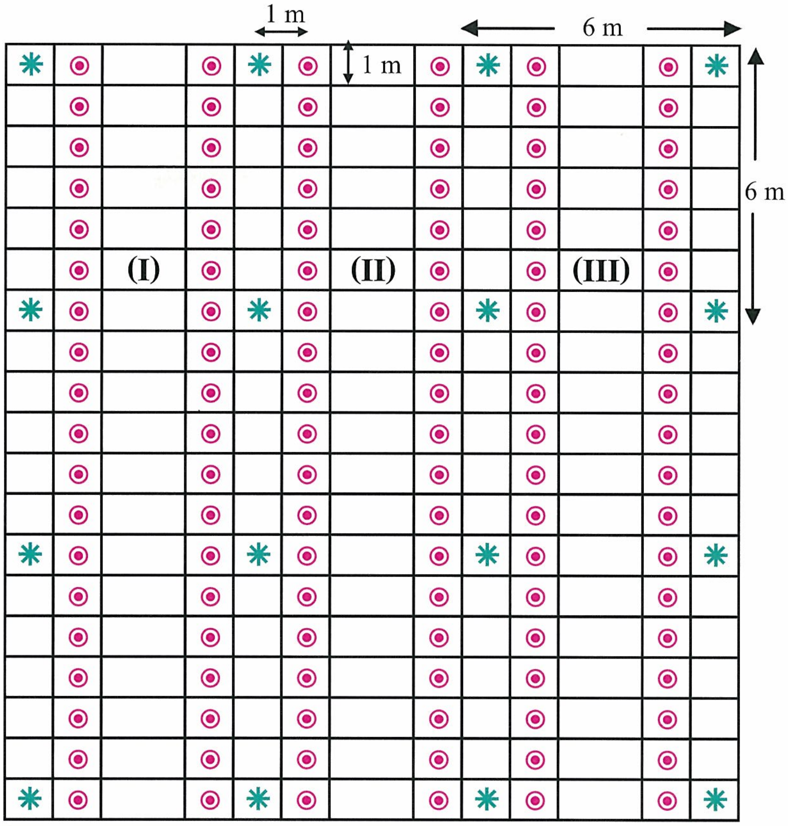
Total height, diameter at ground level and number of shoots were recorded at 18 and 24 months after planting. For each clump, total height and diameter at ground level were measured on every shoot taller than 20 cm. To determine number of leaflets per clump, the number of compound leaves per clump was counted and the number of leaflets per compound leaf estimated using the correlation between number of leaflets and total height as follows.

$$Y = 72.8794 - 0.7438X + 0.0097X^2$$
$$R^2 = 0.99$$
$$P < 0.01$$
$$N = 12$$

Where Y = number of leaflets per compound leaf
X = total height of *C. vimnalis* shoot (cm)

Light Measurement

Diurnal changes in light environment, in term of photosynthetic photon flux density (PPFD), in the planting plot were undertaken on all 6 planting rows compared to full sunlight. The PPFD was recorded every 20 minutes in two days in January 2004 using LI-250 light meter (LI-COR Inc., USA).



✳ *C. quadrangulare*

◎ *C. viminalis*

I: seedlings grown under 15-20% light intensity under *Samanea saman*
II: seedlings grown under 30% light intensity in nursery conditions
III: seedlings grown under 50% light intensity in nursery conditions

Figure 2. Planting lay out of *Calamus viminalis* in *Combretum quardangulare* plantation at the Non-wood Forest Products Experimental Station, Sakon Nakhon province.

Photosynthesis Measurement

Leaf net photosynthesis and related parameters including stomatal conductance, leaf temperature and transpiration were determined in the field using a LI-6400 portable photosynthesis system (LI-COR Inc., USA) as shown in Figure 3. The standard LI-6400 leaf chamber equipped with external LED light source was used and the light intensity (PPFD) was set at 2,000 µmol m^{-2} s^{-1}, thus non-limiting photosynthesis of *C. viminalis*. PPFD, relative humidity, air temperature, and ambient CO_2 concentration were recorded with the LI-6400. Water use efficiency (WUE) was also defined as the ratio of net photosynthesis and transpiration. For each group, measurements were made on 5 clumps and on three fully-expanded leaflets per clump. The measurements were taken place in the morning (8:30 - 9:30 hrs) and afternoon (13:00 - 14:00 hrs) in the dry (February 2004) and wet (September 2004) seasons.

Leaf net photosynthesis and related parameters obtained in this study were then compared to those of 9-year-old *C. viminalis* planted in *Samanea saman* plantation and 9-year-old *C. longisetus* (Waai Kumpuan) and 11-year-old *C. latifolius* (Waai Pong) grown in *Azadirachta excelsa* plantation.

Figure 3. LI-6400 portable photosynthesis system (LICOR Inc.) for leaf photosynthesis measurements of *Calamus viminalis* in the field.

Statistical Analysis

Data in all Tables are presented as means ± standard errors (SE). One-way Analysis of Variance (ANOVA) was employed to analyze statistical differences in growth parameters between groups. Seasonal variations in leaf net photosynthesis and related parameters were analyzed using repeated measures ANOVA. *Post hoc* comparisons between the means were determined using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Seedling Growth Performance

Calamus viminalis seedlings growing under different light environments for one year showed significant difference ($p < 0.01$) in all growth parameters, *i.e.*, total height, diameter at root collar, total dry weight, leaf dry weight, total leaf area, and leaf ratio (the ratio of leaf dry weight to total dry weight) (Table 1). Growth was generally greater among seedlings under 30% (Group II) and 50% (Group III) light intensities for all growth parameters. Particularly, total dry weight of seedlings grown under *S. saman* shade trees was only half of those grown either under 50% or 30% light intensity, probably due to their deep shade environments (only 15-20% of full sunlight). Although the seedlings grown under *S. saman* shade trees relative to the others showed significantly higher leaf ratio, such a high leaf ratio did not contribute to their growth. This may probably because the seedlings were mainly covered by lac, resulting in lower photosynthetic area for their growth (Figure 4).

Figure 4. *Calamus viminalis* seedlings covered with lac after planting under *Samanea saman* shade trees.

Table 1. Total height, diameter at root collar, total dry weight, leaf dry weight, leaf ratio and total leaf area of *Calamus viminalis* seedlings grown under different light environments. For each parameter, values (means ± SE) in the same row followed by the same superscript letter are not significantly different at $p<0.05$ ($n=100$)

Parameters	Group I[1]	Group II[2]	Group III[3]	Mean
Height (cm)	15.20±0.30[a]	24.79±0.56[c]	22.57±0.38[b]	20.85±0.34
Diameter (cm)	1.34±0.02[a]	1.71±0.07[b]	1.86±0.02[b]	1.64±0.03
Total dry weight (gm)	9.37±0.26[a]	19.10±0.68[b]	19.47±0.47[b]	15.98±0.40
Leaf dry weight (gm)	4.33±0.06[a]	7.83±0.10[b]	7.31±0.09[b]	6.49±0.06
Leaf ratio[4]	0.46±0.06[c]	0.41±0.01[b]	0.38±0.0[a]	0.42±0.01
Total leaf area (dm^2)	8.21±0.22[b]	13.68±0.43[c]	10.00±0.22[a]	10.63±0.22

[1] Seedlings grown under *Samanea saman* shade trees
[2] Seedlings grown under 30% light intensity in nursery condition
[3] Seedlings grown under 50% light intensity in nursery condition
[4] The ratio of leaf dry weight to total dry weight

Growth Performance after Planting in *Combretum quardangulare* Plantation

Combretum quadrangulare plantation, with 6 x 6 m spacing, was formerly established for lac culture. Figure 5 shows the diurnal changes in light environment of the *C. viminalis* planted in the *Combretum quadrangulare* plantation compared to those under full sunlight. The diurnal light intensity increased gradually in the morning, reached maximum at noon and declined during the rest of the day. The light intensity measured in the planting plot fluctuated along with that measured in full sunlight and the total light in the planting plot was 11.0 mol m^{-2} day^{-1} or 30.6% of the full sunlight.

Eighteen months after planting in *Combretum quadrangulare* plantation, total height, diameter at ground level and number of shoots per clump, but not the number of leaflets per clumps, of *C. viminalis* from seedlings grown under different light environments varied significantly ($p<0.01$) as shown in Table 2. *C. viminalis* planted seedlings grown under 30% light intensity (Group II) showed the greatest total height and diameter at ground level, while those under 50% light intensity (Group III) had the greatest number of shoots and leaflets per clump.

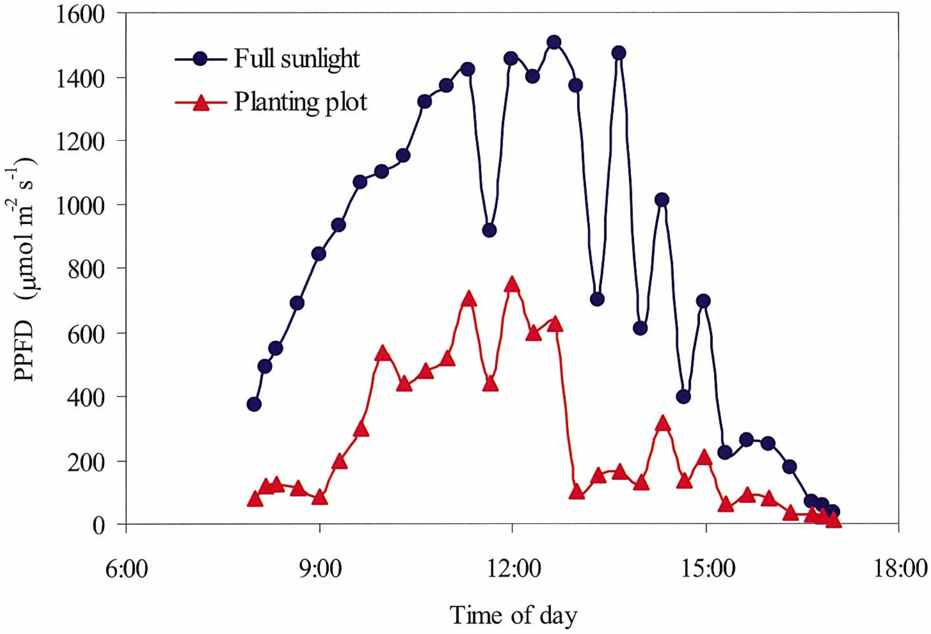


Figure 5. Diurnal changes of light intensity (photosynthetic photon flux density, PPFD) in full sunlight and in the *Calamus viminalis* planting plot under *Combretum quadrangulare*, measured on 8-9 January 2004. For the light intensity in the planting plot, each symbol represents the mean of 6 measurements in different planting rows.

The results also showed that, two years after planting, the Group III *C. viminalis* had larger diameter, more shoots and leaves per clump compared to the others. Although the group II had significantly greater total height, other parameters were comparable. Among 4 parameters, total height showed the greatest variation at both ages determined, while the differences in diameter and number of shoots were rather diminished after two years. Interestingly, *C. viminalis* planted from seedlings grown under *S. saman* shade trees (Group I) had comparable growth performance to the Group III despite smaller seedlings before planting.

Photosynthetic Performance

Table 3 shows leaf photosynthetic performance of *C. viminalis* measured in the dry (February 2004) and wet (September 2004) seasons. The seasonal difference in leaf net photosynthesis and related parameters including, stomatal conductance, transpiration, leaf temperature and water use efficiency was highly significant ($p<0.01$). The difference between morning and afternoon values was also highly significant ($p<0.01$), but significant difference was not found between groups ($p>0.05$).

Table 2. Total height, diameter at ground level, number of shoots per clump and number of leaflets per clump of *Calamus viminalis* planted in *Combretum quadrangulare* plantation using seedlings grown under different light environments. For each parameter, values (means ± SE) followed by the same superscript letter are not significantly different at $p<0.05$ ($n=100$)

Seedling environment	Height (cm)	Diameter (cm)	Shoots per clump	Leaflets per clump
18 months after planting				
Group I	24.80 ± 0.78^{a}	20.19 ± 0.68^{a}	1.44 ± 0.08^{a}	361.2 ± 16.3^{a}
Group II	28.70 ± 0.85^{b}	21.40 ± 0.58^{b}	1.43 ± 0.07^{a}	372.4 ± 15.5^{a}
Group III	26.48 ± 0.93^{ab}	18.40 ± 0.56^{ab}	1.68 ± 0.08^{b}	408.6 ± 15.6^{a}
Mean	**26.66±0.51**	**19.96±0.36**	**1.52±0.05**	**381.3±9.2**
24 months after planting				
Group I	47.29 ± 1.47^{a}	33.92 ± 0.84^{a}	1.81 ± 0.14^{a}	656.1 ± 33.0^{a}
Group II	52.74 ± 1.88^{b}	33.54 ± 0.93^{a}	1.75 ± 0.10^{a}	704.4 ± 39.6^{ab}
Group III	48.11 ± 1.49^{a}	34.03 ± 0.78^{a}	1.99 ± 0.09^{a}	736.8 ± 31.3^{b}
Mean	**49.39±0.95**	**33.83±0.49**	**1.85±0.06**	**699.7±20.1**

[1] Seedlings grown under *Samanea saman* shade trees
[2] Seedlings grown under 30% light intensity in nursery condition
[3] Seedlings grown under 50% light intensity in nursery condition

As expected, leaf net photosynthesis, stomatal conductance and transpiration of the three *C. viminalis* groups declined greatly in the dry season, up to 82, 95 and 82% respectively. Under natural drought condition, CO_2 fixation and stomatal conductance usually decrease in parallel, leading to the assumption that stomatal closure is primarily responsible for the inhibition of photosynthesis under water stress. Rapid stomatal closure decreases not only water loss but also carbon flux to the mesophyll, thereby decreasing photosynthesis (Schulze and Hall, 1982). On the other hand, water use efficiency, the ratio of photosynthetic capacity to transpiration rate, of the 3 groups observed in the dry season largely increased (by

Table 3. Leaf net photosynthesis (A), stomatal conductance (g_s), leaf temperature (T_{leaf}), transpiration (E) and water use efficiency (WUE) of *Calamus viminalis* planted in *Combretum quadrangulare* plantation using seedlings grown under different light environments. For each parameter, values (means ± SE) followed by the same superscript letter are not significantly different at $p<0.05$ (n=15)

Seedling environment	Time	A (μmol m^{-2} s^{-1})	g_s (mol m^{-2} s^{-1})	T_{leaf} (°C)	E (mmol m^{-2} s^{-1})	WUE (μmol(CO_2) mmol(H_2O)$^{-1}$)
			Dry season (January 2004)			
Group I	Morning	5.57 ± 0.35^{b}	0.047 ± 0.003^{a}	29.3 ± 0.5^{a}	0.96 ± 0.08^{a}	6.24 ± 0.53^{bc}
(Under *Samanea saman*)	Midday	2.14 ± 0.21^{a}	0.019 ± 0.001^{a}	35.0 ± 0.2^{e}	0.75 ± 0.05^{a}	2.78 ± 0.19^{a}
	Mean	**3.86 ± 0.38**	**0.033 ± 0.003**	**32.2 ± 0.6**	**0.86 ± 0.05**	**4.51 ± 0.43**
Group II	Morning	5.60 ± 0.32^{b}	0.042 ± 0.004^{a}	29.7 ± 0.4^{a}	0.85 ± 0.06^{a}	6.78 ± 0.32^{c}
(30% light intensity)	Midday	1.59 ± 0.33^{a}	0.015 ± 0.001^{a}	35.3 ± 0.2^{e}	0.62 ± 0.05^{a}	2.35 ± 0.38^{a}
	Mean	**3.59 ± 0.44**	**0.028 ± 0.003**	**32.5 ± 0.6**	**0.74 ± 0.05**	**4.57 ± 0.48**
Group III	Morning	5.56 ± 0.37^{b}	0.055 ± 0.008^{a}	29.4 ± 0.3^{a}	1.05 ± 0.12^{a}	5.75 ± 0.36^{b}
(50% light intensity)	Midday	1.35 ± 0.22^{a}	0.016 ± 0.003^{a}	35.2 ± 0.3^{e}	0.63 ± 0.12^{a}	2.14 ± 0.16^{a}
	Mean	**3.45 ± 0.45**	**0.035 ± 0.006**	**32.3 ± 0.6**	**0.84 ± 0.09**	**3.95 ± 0.37**
			Wet season (September 2004)			
Group I	Morning	11.91 ± 0.39^{de}	1.065 ± 0.048^{e}	31.6 ± 0.4^{b}	4.34 ± 0.14^{c}	2.77 ± 0.14^{a}
(Under *Samanea saman*)	Midday	9.26 ± 0.52^{c}	0.446 ± 0.074^{b}	33.4 ± 0.1^{cd}	3.57 ± 0.28^{b}	2.67 ± 0.11^{a}
	Mean	**10.36 ± 0.43**	**0.704 ± 0.079**	**32.6 ± 0.3**	**3.89 ± 0.19**	**2.71 ± 0.08**
Group II	Morning	10.61 ± 0.43^{d}	0.707 ± 0.046^{c}	32.8 ± 0.1^{c}	4.69 ± 0.22^{c}	2.28 ± 0.07^{a}
(30% light intensity)	Midday	11.50 ± 0.64^{de}	0.741 ± 0.086^{c}	33.5 ± 0.2^{cd}	4.57 ± 0.19^{c}	2.50 ± 0.07^{a}
	Mean	**11.09 ± 0.40**	**0.725 ± 0.050**	**33.2 ± 0.2**	**4.63 ± 0.14^{c}**	**2.40 ± 0.05**
Group III	Morning	10.62 ± 0.82^{d}	0.737 ± 0.078^{c}	32.8 ± 0.1^{c}	4.44 ± 0.15^{c}	2.41 ± 0.20^{a}
(50% light intensity)	Midday	12.31 ± 0.82^{e}	0.906 ± 0.082^{d}	33.7 ± 0.2^{d}	5.37 ± 0.27^{d}	2.29 ± 0.10^{a}
	Mean	**11.46 ± 0.60**	**0.822 ± 0.059**	**33.2 ± 0.2**	**4.91 ± 0.19**	**2.35 ± 0.11**

62-91%) compared to what occurred during the wet season. This is mainly because stomatal closure in response to dry season causes a proportionately greater decrease in transpiration than photosynthesis due to additional resistances associated with the diffusion of CO_2 relative to H_2O in the leaf (Cowan, 1982). Similar physiological responses to seasonal drought were previously reported for some tropical forest tree species (Phasuk, 1999; Royampaeng, 2001; Royampaeng and Woo, 2001; Staporn, 2004) and some bamboo species (Puangchit and Ishizuka, 2000).

The results also show that the difference in leaf net photosynthesis, stomatal conductance and transpiration of all three groups measured in the morning and afternoon was more pronounced in the dry season as compared to the wet season (Table 3). The great decline in the afternoon observed in the dry season could probably be due to water stress and/or high leaf temperature. Obviously, the leaf temperature of all groups increased more than 5 degrees Celsius in the afternoon. Under such conditions, stomata were partly closed to minimize leaf water losses through transpiration which, in turn, reduced photosynthesis as noted in many tropical tree species (Royampaeng 2001; Diloksumpun *et al.*, 2003; Diloksumpun *et al.*, 2004) and some bamboo species (Puangchit and Ishizuka, 2000). However, the values of water use efficiency determined in the morning were over two-fold higher than those in the afternoon, indicating a proportionately greater decrease in photosynthesis relative to transpiration in the afternoon.

Although *C. viminalis* exhibited non-significant difference in photosynthetic performance between groups (p>0.05), the variations cannot be overlooked (Table 3). In wet season, the highest leaf net photosynthesis and transpiration were found in Group III, while the highest water use efficiency was observed in Group I (Figure 6). In dry season, on the other hand, the seedlings in Group I had the greatest leaf net photosynthesis and transpiration, while those of Group II had highest water use efficiency. The results suggested that the Group I seedlings were able to maintain higher leaf photosynthetic activity in the dry season where water availability became limited. Contrarily, the Group II seedlings were able to minimize water losses through leaf transpiration under such stress condition, resulting in water use efficiency.

In the present study, the morning values of net photosynthesis of the seedlings in all three groups measured in the wet season were considerably lower (18-32%) than those of 9-year-old *C. viminalis* grown under *S. saman* (Table 4). This is probably because the latter was planted with a 3 x 2 m spacing under *S.*

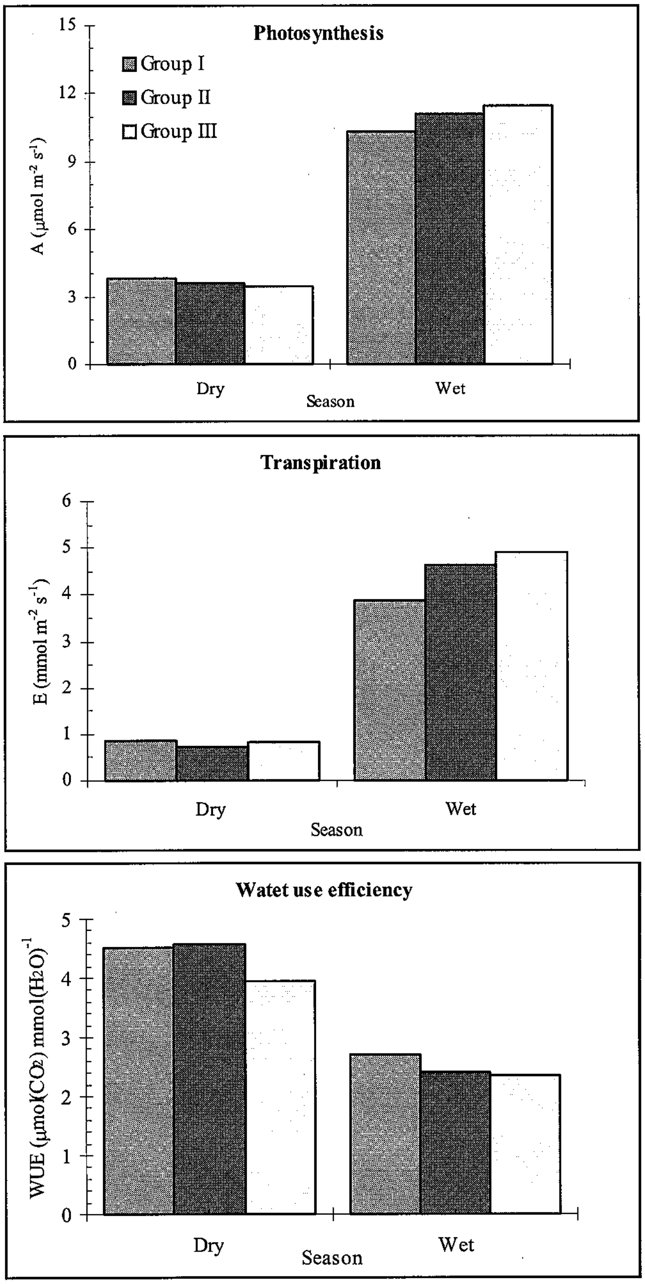


Figure 6. Mean net photosynthesis, transpiration and water use efficiency of *Calamus viminalis* planted in *Combretum quadrangulare* plantation: Group I– seedlings grown under *Samanea saman*; Group II- seedlings grown under 30% light intensity and; Group III- seedlings grown under 50% light intensity.

saman with spacing of 10 x 10 m, resulting in higher light availability. Evidently, they exposed to rather higher light intensity (about 60% of full sunlight) compared to only 30% of the former, thereby increasing photosynthesis. Within the same species, greater photosynthetic capacity was previously noted in many species when grown under high light conditions (Royampaeng, 2001). In addition to wider spacing, higher photosynthesis of the 9-year-old *C. viminalis* could be partly contributed to difference in their ages.

The results presented in Table 4 also emphasize the long term shade adaptation of *C. viminalis* in terms of photosynthetic parameters. It shows non-significant difference in photosynthetic parameters ($p>0.05$), including leaf net photosynthesis, transpiration and water use efficiency, between the 9-year-old *C. viminalis* grown in full sunlight and under *S. saman* trees. This may partly be attributed to comparatively high light intensity due to wide planting space of *S. saman*.

Table 4 Leaf net photosynthesis, transpiration, water use efficiency and photosynthetic photon flux density (PPFD) of 9-year-old *Calamus viminalis* grown in full sunlight and under *Samanea saman* trees (n=10)

Light environment	**Photosynthesis** (μmol m^{-2} s^{-1})	**Transpiration** (mmol m^{-2} s^{-1})	**WUE** (μmol(CO_2) mmol(H_2O)$^{-1}$	**PPFD** (μmol m^{-2} s^{-1})
In full sunlight	14.79±0.13	5.39±0.10	2.86±0.07	988.6±1.5
Under *S. saman*	14.05±0.11	4.96±0.07	2.77±0.07	578.3±1.5
P-value	>0.05	>0.05	>0.05	<0.05

Note: all parameters were measured in the morning during the transition from wet to dry seasons (November 2002).

In addition, the photosynthetic performance of *C. viminalis* in the present study was compared with that of 9-year-old *C. longisetus* and 11-year-old *C. latifolius* grown in *A. excelsa* plantation, Krabi province. The 2-year-old *C. viminalis* showed greater leaf net photosynthesis than the 9-year-old *C. longisetus* and 11-year-old *C. latifolius* respectively despite lower relative light intensity. The finding suggests that *C. viminalis* might be able to adapt better under the shade conditions.

Application for Silvicultural Practices

Manipulation of suitable light intensity for rattans planted in forest plantations is of great importance. Tan (1992) previously reported that 40 to 50% light intensity appeared to be optimum for vigorous growth of some commercial rattan species. Bacilieri *et al.* (1996) also emphasized that light intensity was positively correlated to growth of the rattan. In addition to adequate light availability for photosynthesis, high relative light intensity induced a faster turnover of the leaves and growth of some rattan species was closely related to the production rates of new leaves (Mori, 1980). In the current study, the relative light intensity observed in *C. viminalis* in *Combretum quadrangulare* plantation was rather low (Table 5). Growth performance of *C. viminalis* in the present study could probably be increased by manipulating the *Combretum quadrangulare* canopy to create more light availability to increase photosynthesis.

Table 5 Net photosynthesis and transpiration of *Calamus viminalis* (Waai Dong) grown in *Samanea saman* and *Combretum quadrangulare* plantation and *C. longisetus* (Waai Kumpuan) and *C. latifolius* (Waai Pong) grown under *Azadirachta excelsa* plantation

Species	Age (years)	Plantation	Light intensity[4]	Photosynthesis (μmol m^{-2} s^{-1})	Transpiration (mmol m^{-2} s^{-1})
C. viminalis[1]	2	*S. saman*	30.6%	10.97±0.48	4.48±0.17
C. viminalis[2]	9	*C. quadrangulare*	58.5%	14.05±0.11	4.96±0.07
C. latifolius[3]	9	*A. excelsa*	41.3%	8.79±0.46	2.45±0.14
C. longisetus[3]	11	*A. excelsa*	32.1%	6.01±0.41	1.62±0.11

[1] Data undertaken in November 2002
[2] Data undertaken in September 2004
[3] Data undertaken in January 2002
[4] Relative light intensity (photosynthetic photon flux density) to full sunlight

In addition, rattan seedlings normally need shade to grow well. The optimum shade, which can be provided by using shade clothes in nursery or by manipulating under forest plantation, for raising young rattan seedlings was generally about 50% (Mori, 1980; Wan Razali *et al.*, 1994; Ramyarangsi and Satitviboon, 1997). The seedlings used in this study were exposed to different light conditions, both under forest plantation and nursery conditions. *C. viminalis* seedlings grown under 30 and 50% light intensities in nursery exhibited superior growth performance to those grown under *S. saman* trees. Growth of seedlings grown under *S. saman* trees was limited not only by lower relative light intensity (about 15 - 20%) but also by their leaves mainly covered with lac. To establish rattan nurseries in forest plantation, even simple and ready made, some disadvantages should be, therefore, taken into consideration as follows: (1) seedlings are often damaged by falling tree branches; (2) it is difficult to achieve uniform shade/light conditions for the whole nursery; (3) seedlings often covered by leaf litter; and (4) surface roots of some trees can start to grow into seedling bags and compete for water and nutrients. However, a large well-managed rattan nursery has been successfully established by SAFODA (Sabah Forest Development Authority) in *Acacia mangium* plantation where light was adequate and uniform and there were no bulging root systems on the ground surface (Wan Razali *et al.*, 1994).

Finally, development of rattan plantation for sustainable uses involves not only silvicultural practices but also genetic improvement in order to grow different species in new or modified environments. Although very little improvement research was in progress prior to 1990, more attention has recently been given to rattan improvement in some Southeast Asian countries. Particularly, rattan improvement programs, *i.e.*, reproductive biology, species trials, provenance trials, progeny tests and vegetative propagation, in Malaysia, the Philippines and Indonesia are noteworthy (Shim, 1995). In Thailand the research work on rattan phenology and vegetative propagation have been reported (Jarernrattawong, 1996). Being one of the most promising rattan species widely planted for commercial shoot production in northeastern region, genetic improvement program for *C. viminalis* in Thailand is, therefore, required.

CONCLUDING REMARKS

The *C. viminalis* seedlings grown under 30 and 50% light intensities showed better growth performance compared to those under *S. saman* shade trees, The latter having only 50% of the total dry weight of the other two groups, probably due to their deep shade environments (only 15 - 20% full sunlight) and/or their leaves covered with lac.

Overall, *C. viminalis* planted from seedlings grown under 30 and 50% light intensities adapted well after planting in *Combretum quadrangulare* plantation where the light intensity was about 30% of full sunlight. Interestingly, in the long term, *C. viminalis* from seedlings under *S. saman* shade trees tended to adapt well under shading environments even though it had lower growth rate before planting. Furthermore, photosynthetic performance of all the three groups was similar in the wet season but slightly different in their responses to seasonal drought during the dry season. *C. viminalis* grown from seedlings under *S. saman* trees was able to maintain higher leaf photosynthetic activity in the dry season where water availability became limited, while that from seedlings under 30% light intensity was able to minimize water losses through leaf transpiration under such stress condition, resulting in greater water use efficiency. Further research on physiological processes contributed to rattan growth as well as genetic improvement is, therefore, recommended for sustainable management of *C. viminalis* plantation.

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Determination of Soil Characteristics under Rattan Experimental Plots of the Project Sites

by

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Determination of Soil Characteristics under Rattan Experimental Plots of the Project Sites

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The studies on soil characteristics in rattan experimental plots of the project sites were carried out in Narathiwat, Krabi and Sakon Nakhon provinces. The study areas were set in various rattan experimental plots including forest and encroachment areas. The results of soil surveys revealed that Reddish Brown Lateritic Soils covered the plots in Narathiwat. These soils were deep and moderately well drained with reddish brown sandy loam topsoil. Distinct lateritic soils were found in lower horizons. The evaluated soil fertility was low. Red Brown Earths were found in the plots in Krabi province. These soils were poorly drained with dark reddish brown clayey texture and medium fertility. The soils in the Sakon Nakhon experimental plots were Gray Podzolic Soils developed from old alluvium on fans. Soil profile diffused in smooth boundary with any distinct strong brown iron mottles and low fertility. The results of the studies described the characteristics of soils in rattan experimental plots. Information of soil properties together with the growth rate of rattan species will be used to evaluate suitability site for rattan species.

INTRODUCTION

Rattans have long been recognized in Thailand for its commercial values. Natural forests are the major supply of rattan in the country mainly in forms of canes and young shoots. Demand for rattans as important raw materials for handicraft, furniture and other products are rising, while natural sources are diminishing. It is therefore important to establish rattan plantation in order to fulfill the increasing demand. However, different rattan species require different sites and optimum conditions to grow. Soil is one of the major factors influencing

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growth performance of plant species. The study of soil characteristics in experimental plots of rattan is a major key that would reveal important data and information needed for establishment of sustainable rattan plantation in Thailand.

MATERIAL AND METHODS

Study Sites

The study was conducted in various rattan experimental plots in Narathiwat, Krabi and Sakon Nakhon provinces. The details of each site are as follows.

1. **Narathiwat Province**

   1.1 *Calamus caesius* planted in natural forest (Tropical Rain Forest), in 1986 at Ban Toh Moh, Sukirin district, Narathiwat province (NRW_1).

   1.2 Three rattans species, *i.e.*, *Calamus floribundus, Calamus caesius* and *Calamus manan* planted in rambutan orchard in encroachment area and incorporated under 'Little House in the Big Forest Plantation Project' at Ban Ire Ba Joh, Phu Khao Thong district, Narathiwat province (NRW_2).

   1.3 Living collection of *Calamus caesius* in swamp forest at Ban Sungai Padi, Sungai Padi district, Narathiwat province (NRW_3) in commemoration for Her Majesty Queen Sirikit's Sixtieth Anniversary.

2. **Krabi Province** (Nai Chong Rattan Seed Production Area Station, Tambon Khao Thong, Khao Thong district, Krabi province)

   2.1 Plot of *Calamus latiflorus* and *Calamus longiseta* in Neem (*Azadirachta excelsa*) plantation in 1987 (KRB_1).

   2.2 *Calamus manan* planted between the planting rows of *Dipterocarpus alatus* (KRB_2).

   2.3 *Calamus manan* planted in *Dipterocarpus alatus* plantation (KRB_3).

3. Sakon Nakhon Province

3.1 Plot of *Calamus viminalis* and *Calamus* spp. for shoot production at different planting spaces.

3.2 Experimental plot of various rattan species for canes and shoot production.

3.3 Experimental plot of various rattan species for production of different raw materials with experimental purposes.

Some experimental plots were also established on farmers' land for shoot production.

Methodology

1. Field Study

1.1 The studied plots were inventoried and selected as a representative area on each site.

1.2 The preliminary survey was done by digging the topsoil to the depth of 20 – 30 cm and samples were taken from the subsoil to the depth of approximately 1.20 – 1.50 m using soil auger. The aligned samples were used to check for physical and chemical characteristics of soil such as color, texture, structure and pH. All characteristics were recorded for further classification of soil and soil boundary demarcation.

1.3 From preliminary survey information, the great soil group at each site was classified using the USDA Soil Classification System (Soil Survey Staff, 1994). The soil pit of 1 x 1.5 m and 1.5 m depth was dug for undertaking soil profile descriptions.

1.4 Both disturbed and undisturbed soil samples were collected from each soil horizon for analysis in the laboratory.

2. Laboratory Work

The soil samples were air-dried at room temperature in preparation room and then ground in porcelain mortar and sieved through 2 mm mesh. The prepared samples were analyzed for pH, available P, organic matter (OM), exchangeable cations (K, Ca, Mg and Na), cation exchange capacity (CEC), base saturation (BS), soil texture and bulk density in the laboratory using methods described by Black (1965).

3. Data Analyses

The data from the field and from the laboratory works were analyzed to describe soil type, soil characteristics, both for chemical and physical properties. The soil fertility of the soil at each site was evaluated using the method described by FAO Project Staff and Land Classification Division (1973) and Soil Survey Division, Department of Land Development (1976).

RESULTS

The results of the study of soil characteristics in various rattan experimental plots in three provinces (three sites in Narathiwat province, three sites in Krabi province and six sites in Sakon Nakhon province) were shown as follows.

Narathiwat Province

The studied plots were in tropical rain forest that developed on alluvial soils with scattered rock outcrops on the surface. The topography was flat to undulating with the slope lied between 1 to 6%. The soils were poorly to moderately well drainage.

The depth of the topsoil was not more than 15 cm. The soil texture was sandy loam with reddish brown color throughout the profile. These soils were rather compacted when dry and sticky when wet. The topsoil in the studied plots was extremely acidic with the average pH of 4. The brown and reddish brown mottles with some layers of weathering rocks were found in the lower part of the profile. There were also small and big conglomerates coated with manganese oxide and big granites found in the deeper horizons. The subsoil was very strongly acidic with the pH of 4.5.

The results of the soil sample analysis (Table 1) showed that the top soils had high organic matter, low base saturation, low cation exchange capacity, very low available P and very low exchangeable K. The subsoil had low levels of base saturation, cation exchange capacity, available P and exchangeable K.

The results from the studies of chemical and physical characteristics of these soils revealed that the soils in these experimental plots had very low nutrient contents with moderately well physical properties, and low fertility.

Krabi Province

The studies of various rattan experimental plots in Krabi province were established in encroachment area as part of restoration program. The general topography of the planting area was undulating with the average slope between 2 to 5%. These soils, developed from alluvial soils, had poor drainage and moderately well permeability.

The depth of the topsoil was not more than 20 cm. The soil texture was clayey with dark reddish brown color on the top. The topsoil in the plots was extremely acidic (pH 4.3), moderately poor drainage with accumulation of organic matter. The mottles of iron oxide and manganese oxide were found at the depth lower than 15 cm. The subsoil was also clayey. The traces of shiny cutans were found mixed in the lower part of the reddish clayey profile. They were very acidic to very strongly acidic with the pH of 4.5 – 5.5.

The results of soil analysis (Table 1) showed that the topsoil had medium organic matter, low base saturation, moderately low cation exchange capacity, low available P and low exchangeable K. The subsoil, at the depth from 30 cm, had low levels of base saturation, cation exchange capacity, exchangeable K and very low level of available P. In summary, these soils had medium to low nutrient contents and evaluated to have low to medium fertility.

Sakon Nakhon Province

The studied plots were in dry dipterocarp forest that developed on alluvial soils. The topography was flat to undulating. The soils were characterized by deep and moderately deep to somewhat moderately poor drainage with low permeability.

The depth of the topsoil was approximately 20 cm. The soils had very fine loamy sand texture on the top and very fine sandy loam texture in the lower part. The drainage of the soils was moderate to somewhat moderately poor. The topsoil contained many roots with strong brown color. They were strongly acidic (pH 5.1). The subsoil was brown to strong brown in color with some distinct strong brown mottles of iron oxide and manganese oxide and lateritic gravels. They were strongly acidic to very strongly acidic with the pH of 5.0 – 5.5.

Table 1. Properties of soil at experimental sites in Narathiwat

Site	Horizon	Depth (cm)	pH 1:1 H_2O	OM (%)	Avail. P (ppm)	Exch. Cation me/100 g (ppm)				CEC me/ 100	B.S. (%)	(%) Soil composition			Texture	Bulk density (g/cm^3)
						K	Ca	Mg	Na			Sand	Silt	Clay		
Nara-	A	0-10	3.80	4.25	4.20	0.137	0.592	0.202	0.031	8.72	11.03	55.00	29.00	16.00	SL	0.94
thiwat	B	10-40/55	4.46	4.99	0.68	0.089	0.171	0.176	0.048	3.17	15.25	56.00	26.00	18.00	SL	1.31
	BC	40/55+	4.53	2.88	2.27	0.096	0.311	0.274	0.042	2.93	24.68	54.00	26.00	20.00	SL	1.35
Krabi	A	0-13	4.33	3.68	2.11	0.138	0.429	0.684	0.255	9.80	7.59	34.00	18.00	48.00	C	0.97
	B1	13-45	4.58	2.03	1.01	0.050	0.106	0.159	0.262	10.96	22.55	18.00	14.00	68.00	C	0.99
	B2	45-70	4.87	1.00	1.10	0.033	0.079	0.158	0.264	10.22	17.57	9.64	14.36	76.00	C	0.87
	B3	70+	5.14	1.23	0.37	0.036	0.069	0.100	0.333	8.81	10.93	9.64	12.36	78.00	C	0.90
Sakon	A	0-15	5.11	1.37	nil	0.119	2.914	1.283	0.487	6.40	75.01	85.00	10.00	5.00	LS	1.45
Nakhon	B1	15-30	5.69	0.33	nil	0.069	2.030	0.693	0.479	4.27	76.59	80.00	6.67	1.33	SL	1.52
	B2	30-50	5.45	0.28	nil	0.078	2.101	1.685	0.458	5.92	72.98	74.17	7.50	18.33	SL	1.57

The results of soil analysis (Table 1) showed that the topsoil had low organic matter, high base saturation, moderately low cation exchange capacity, very low available P and low exchangeable K. The subsoil, at the depth below 20 cm, had moderately high base saturation, low cation exchange capacity, very low available P and low exchangeable K. In summary, these soils had low nutrient contents and evaluated to have low fertility.

DISCUSSION

The studies on soil characteristics in various rattan experimental plots in natural forest and encroachment area were carried out in Narathiwat, Krabi and Sakon Nakhon provinces. The results revealed that the soils in each studied site were different in characteristics (Table 2). At the plots in Narathiwat province, the soils were Reddish Brown Lateritic Soils. These soils were moderately well drained with reddish brown sandy loam throughout the profile. The distinct lateritics of low fertility were found in the subsoil. Within those plots in Krabi province, the soils were Red – Brown Earths which were shallow, poorly drained with dark reddish brown topsoil and clayey throughout the profile. Mottles of iron oxide and manganese oxide were found mainly in the subsoil. The soil fertilities at this study site were poor to moderate. The soils in experimental plots in Sakon Nakhon province were Gray Podzolic soils which were brownish throughout the profile with stronger shade on topsoil. The textures of the soil were sandy loam on the top and loamy sand in the lower part of the profile, with low fertility. Mottles of iron oxide and manganese oxide were found in the subsoil.

The results clearly indicated different Soil Groups and different soil characteristics among experimental plots. This useful information will be further evaluated with other studies, especially growth performance in order to determine the important relationships that will be used for successful establishment of rattan plantations in Thailand.

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Table 2. Characteristics of soil at rattan experimental plots in Narathiwat, Krabi, and Sakon Nakhon provinces

Items	Narathiwat	Krabi	Sakon Nakhon
Land use	Tropical Rain Forest	Forest Encroachment/Reforestation	Dry Dipterocarp Forest
Parent materials	Alluvial Soils	Alluvial Soils	Allurial Soils
Top soil	Rock Out Crops	Shallow Soil (topsoil < 15 cm)	Deep Soil (topsoil > 20 cm)
Soil colour	Reddish Brown	Dark Reddish Brown to Red	Very Strongly Brown to Strongly Brown
Soil texture	Sandy Loam - Very Gravelly Sandy Loam	Clay	Loamy Sand to Sandy Loam
Drainage	Moderately Well Drained	Poor Drained	Moderately Well Drained
Soil reaction	pH ~ 3.8 - 4.5 (Extremely Acid - very strongly Acid)	pH ~ 4.5 - 5.5 (Very strongly Acid - Medium Acid)	pH 5.0 - 5.5 (Very Strongly Acid - Strongly Acid)
Soil Fertility	Low Soil Fertility	Medium to Low Soil Fertility	Low Soil Fertility

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APPENDIX 1

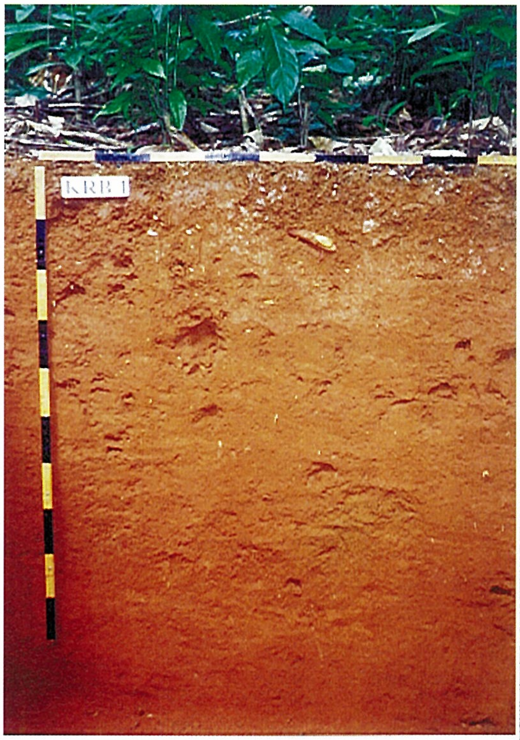
Soil Profile No. **NRW1**	
Province	Narathiwat
District	Sukirin
Location	Ban Toh Moh
Organization	Dept. of National Park, Wild life and Plant Conservation
General information of site	
Stand	*Calamus caesius*
Altitude	-
Slope on which profile is site	
inclination	6^{o}
direction	-
mode	slightly slope
Parent material	granite
Classification	Reddish Brown Lateritic Soils

Profile Description of NRW1

Horizon	Depth (cm)	Description
A	0-10	Reddish brown (2.5YR 4/3); sandy loam; weak medium and coarse sub-angular blocky; slightly hard, firm moist, very sticky and plastic wet; few course and medium, and many fine and very fine roots; distinct of organic matter, and rock out crop was found on the surface; extremely acid (pH ~ 3.8); gradual and smooth boundary.
B	10-40/55	Reddish brown (2.5YR 5/4); sandy loam; moderate medium sub-angular blocky; slightly hard dry, very friable moist, slightly sticky and plastic wet; common fine and very fine roots; very few small distinct of many continuous reddish gray (5YR 5/2) mottles; extremely acid (pH ~ 4.4); gradual and smooth boundary.
BC	40/55+	Reddish brown (2.5YR 5/3); very gravelly sandy loam; moderate medium and coarse sub-angular blocky; slightly hard dry, very friable moist, slightly sticky and slightly plastic wet; few fine and very fine roots; distinct of dominant rounded gravel, frequent small rounded gravel of manganese oxide and dominant medium and large angular of iron and manganese oxide, few large angular boulders (47, 83 cm) of granite; very strongly acid (pH ~ 4.5).

APPENDIX 2

Soil Profile No.	**KRB1**
Province	Krabi
District	Muang
Location	Khao Thong
Organization	Royal Forest Dept.
General information of site	
Stand	*Azadirachta excelsa, Calamus latiflorus, Calamus longiseta*
Altitude	200 m
Slope on which profile is site	
inclination	5^{o}
direction	-
mode	slightly flat
Parent material	-
Classification	Red – Brown Earths



Profile Description of KRB1

Horizon	Depth (cm)	Description
A	0-13	Dark reddish brown (2.5YR 3/4); clay; moderate fine and medium sub-angular blocky; hard dry, very firm moist, sticky and plastic wet; many fine and very fine and few medium roots; distinct of many humus and charcoal; few fine faint distinct of many iron oxide and many manganese oxide; many grass roots; extremely acid (pH 4.3); gradual and smooth boundary.
B1	13-45	Red (2.5YR 4/6); clay; moderate fine and medium sub-angular blocky; slightly hard, very friable moist, slightly sticky and slightly plastic wet; few coarse, common medium and fine roots, distinct of many termite holes; few thin faint clay coatings in ped pores; very strongly acid (pH 4.5); gradual smooth boundary.
B2	45-70	Red (2.5YR 4/8); clay; moderate fine and medium sub-angular blocky; soft dry, very friable moist, slightly sticky and slightly plastic wet; few medium, fine and very fine roots; very few thin faint clay coatings in ped pores; distinct of few fine and medium termite holes; very strongly acid (pH 4.8); gradual smooth boundary.
B3	70+	Red (2.5YR 4/8); clay; moderate fine sub-angular blocky; soft dry, very friable most, slightly sticky and slightly plastic wet; few fine and very fine roots; distinct of few termite holes; strongly acid (pH 5.1).

APPENDIX 3

Soil Profile No. **SKN1**	
Province	Sakon Nakhon
District	Muang
Location	Huay Yang
Organization	Royal Forest Dept.
General information of site	
Stand	*Calamus viminalis*
Altitude	240 m
Slope on which profile is site	
inclination	0^o
direction	S 80^o E
mode	flat
Parent material	sand stone
Classification	Gray Podzolic Soils

Profile Description of SKN1

Horizon	Depth (cm)	Description
A	0-20	Very strong brown (7.5YR 2.5/2); loamy sandy; weak medium to fine sub-angular blocky; hard dry, very friable moist, slightly sticky and slightly plastic wet; common, medium fine and very fine roots; distinct of humus; and many charcoal, strongly acid (pH ~ 5.1); diffuse and smooth boundary.
B1	20-45/60	Brown (7.5YR 4/4); sandy loam; moderate coarse medium and fine sub-angular blocky; hard dry, firm moist, slightly sticky and slightly plastic; coarse few, common medium, common fine and very fine many medium and fine iron distinct strong brown (7.5YR 4/6) mottles; medium acid (pH ~ 5.7); diffuse and smooth boundary.
B2	45/60+	Strong brown (7.5YR 3/4); sandy loam; moderate medium to fine sub-angular blocky; hard dry, friable moist, slightly sticky and plastic wet; few coarse, common medium and few fine roots; many distinct strong brown (7.5 YR 5/8) iron mottles; few manganese concretions; few large termite-holes; strongly acid (pH 5.5).

Rattan Shoot Processing Techniques

by

Pannee Denrungruang

PD24/00 Rev.1(I)

Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

Royal Forest Department

Thailand

October 2004

Rattan Shoot Processing Techniques

Pannee Denrungruang[1]

There are more than 60 species of rattan in Thailand, but only one species of Calamus is well known in the northeastern region as the species with most favorite edible shoots. This species is referred to as Waai Dong that is extensively planted in the areas of Sakon Nakhon province. The cane of this rattan species is medium-sized with diameter of 2.0-2.5 cm. The study on rattan shoot processing was conducted in order to find out the possibility for rattan shoot preservation as well as to encourage the farmers who are interested in rattan shoot production. The rattan shoots were put into a 6 oz. glass bottle filled with a mixture of brine of 2% and syrup 30% concentrations adjusted with citric acid for pH below 4.5. The products of rattan shoots in brine and syrup were kept in room temperature for microorganism examination for 3 and 6 months. There was no microorganism found in rattan shoot product. The nutritive value of rattan products showed little change from fresh rattan shoot in protein and fat. The energy (Kcal) from rattan shoot in syrup was higher than that in brine, because of sucrose. The dehydrated product was better in texture and color. The results of sensory evaluation between two treatments, rattan shoot in brine and rattan shoot in syrup indicated that the mean of sensory evaluation was between 3.69 to 4.90 and the products were accepted by panelists.

INTRODUCTION

Rattans are climbing palms that have been utilized for centuries in several Asian countries and their economic important are second to the forest trees. Rattans are mainly used to make furniture household utensils and home decorates. However, the use of rattan shoots as vegetable has been mentioned in many areas. According to Renuka (2001), young leaves, roots and shoot tips of rattan have been used as

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medicines and as vegetable by some indigenous people in Bangladesh. Recently, rattan shoot are popularly consumed and sold in some local areas. Instead of waiting for 6 - 7 years to obtain the cane for utilization, rattan shoots can be harvested within 2 years after planting. Using rattan shoot as an ingredient in many kinds of food is becoming popular especially in northern, northeastern and central parts of Thailand. Moreover, people in Laos and Vietnam are also fond of consuming rattan shoots and demand is increasing. It can be expected that local and international markets of rattan shoots are expanding. The most common rattan species planted for shoot production in Thailand are Waai Nam Pung (*Calamus siamensis*) and Waai Dong (*C. viminalis*) that are bitter tasted. Fresh shoots become a popular souvenir from the Northeast, while people in central region begin to know how to prepare food from rattan shoots.

Rattan is very useful in pharmaceutical point of view. The ashes of the stem of *Calamus ornatus* Blume are used for treatment of chromic or returning, yaws. An infusion of the root is used to reduce the pain in child-birth and ethanol (50%) extract of aerial part antianeer (Burkill, 1966). *Calamus acathophyllus* Becc. is prescribed for treating malaria and jaundice; the roots are used as a compound against nausea (Perry, 1980). In central and southern India, the roots of *Calamus rotang* Linn. are astringent, acid bitter, cooling, expectorant, alexeteric, antidysenteric, hypotensive, depurative, anti-inflammatory, diuretic, febrifuge and tonic. The leaves are acrid, bitter, cooling, astringent and laxative and are useful in vitiated conditions of pitta, skin diseases, leprosy and pruritus. The seeds are astringent, acrid, sour, depurative and expectorant, and are useful in vitiated conditions of kapha, cough, skin diseases and pruritus. The sprouts are acrid, sweet and thermogeni and are useful in tithed condition of vata and kapra (Sala, 1994).

OBJECTIVE

The objective of the study was to develop the techniques for processing, packaging and chemical properties of rattan shoot products.

MATERIAL AND METHODS

Raw Material

- Young shots of Waai Dong (*Calamus* sp.)

Chemicals

- Sodium metabisulphite ($Na_2S_2O_3$)
- Citric acid
- Calcium chloride ($CaCl_2$)
- Sodium chloride (NaCl)
- Sugar

Equipment

- Oven
- Autocave
- Kitchen utensils
- Gas cooker
- Glassware
- etc.

Test Methods

1) Microorganism examination of rattan shoots in brine and syrup 3 and 6 months after processing was conducted at Department of Medical Science, Ministry of Public Health.

2) The nutritive value of rattan shoots and rattan products was analysed by Nutrition Division, Department of Health, Ministry of Public Health.

3) Physical properties test after 6 months.

Methodology

Processing of Bottled Rattan Shoots in Brine Solution

Young shoots (Annex Figure 1) of *Calamus viminalis*, bought from the farmers, were peeled by taking off the leaf-sheaths and skin by knife (Annex Figure 2). The shoots, opaque white color with diameter of 0.25-0.50 inch, were cut in pieces of about 3 ¼ inches long. The shoots were then boiled for 10 minutes in blanching solution (Annex Figure 3) that contained 0.1% sodium metabisulphite and 0.2% citric acid in water, followed by cooling in 0.1% sodium metabisulphite solution. The materials were put in the 6-oz. glass bottle (Annex Figure 5) filled with boiling brine solution contained 2% salt, 0.5% citric acid and 0.1% calcium chloride. The headspace was about ½ inch on the top of the glass bottle. Samples were then at exhausting process where the open glass bottles were heated in boiling water for about 15 minutes before being closed (Annex Figure 5). After exhausting process, the glass bottles were placed in boiling water (100 °C) for about 30 minutes (Annex Figure 6). In case of bottled rattan shoot industry, the processing should be done in an autoclave under the steam pressure of 10 pounds per inch for 15 minutes instead of 30 minutes in boiling water (Annex Figure 7). The finished products were kept under room temperature (Annex Figure 8).

Processing of bottled rattan shoots in syrup solution

Rattan shoots (*Calamus viminalis*) raw materials were prepared exactly by the same process as those in brine solution. Rattan shoots were put in the 6-oz. glass bottle filled with syrup solution that contained 30% sucrose, 0.5% citric acid and 0.1% calcium chloride in water. The headspace is about ½ inch in the top of the glass bottles. Samples were under exhausting process, the open glass bottles being heated in boiling water for about 15 minutes and closed the lids. After exhausting process, the materials were put through sterilized process by placing the glass bottles in boiling water (100 °C) for about 30 minutes. Processing of rattan shoots at industrial scale should be done in autoclave.

Processing of sun-dried and dehydrated rattan shoots

Rattan shoots already prepared were cut in pieces of about 1 ½ inches long and put in 0.1 % sodium metabisulphite. The materials were then boiled for 10 minutes in blanching solution that contained 0.1% sodium metabisulphite and 0.2% citric acid before being cooled in 0.1 percent sodium metabisulphite solution. After cooling process, the shoots spread on mats or trays and kept outdoor for sun-drying. It would take 3 to 4 days for the shoots to be dried up. Under dehydration process, rattan shoots were placed in drying chamber at 70 °C for about 10 hours (Annex Figure 9) from which the product was better in texture and color (Annex Figure 10).

RESULTS AND DISCUSSION

Rattan shoot raw materials used for glass bottling, sun-drying or dehydrating were the soft edible part with white or cream in color with a little bitter taste. The processes for preparing rattan shoots in brine solution are presented in Figure 1, syrup solution in Figure 2 and drying in Figure 3. There was no microorganism found in bottled rattan shoots in brine and syrup solutions after being kept for 3 months and 6 months, respectively (Table 1).

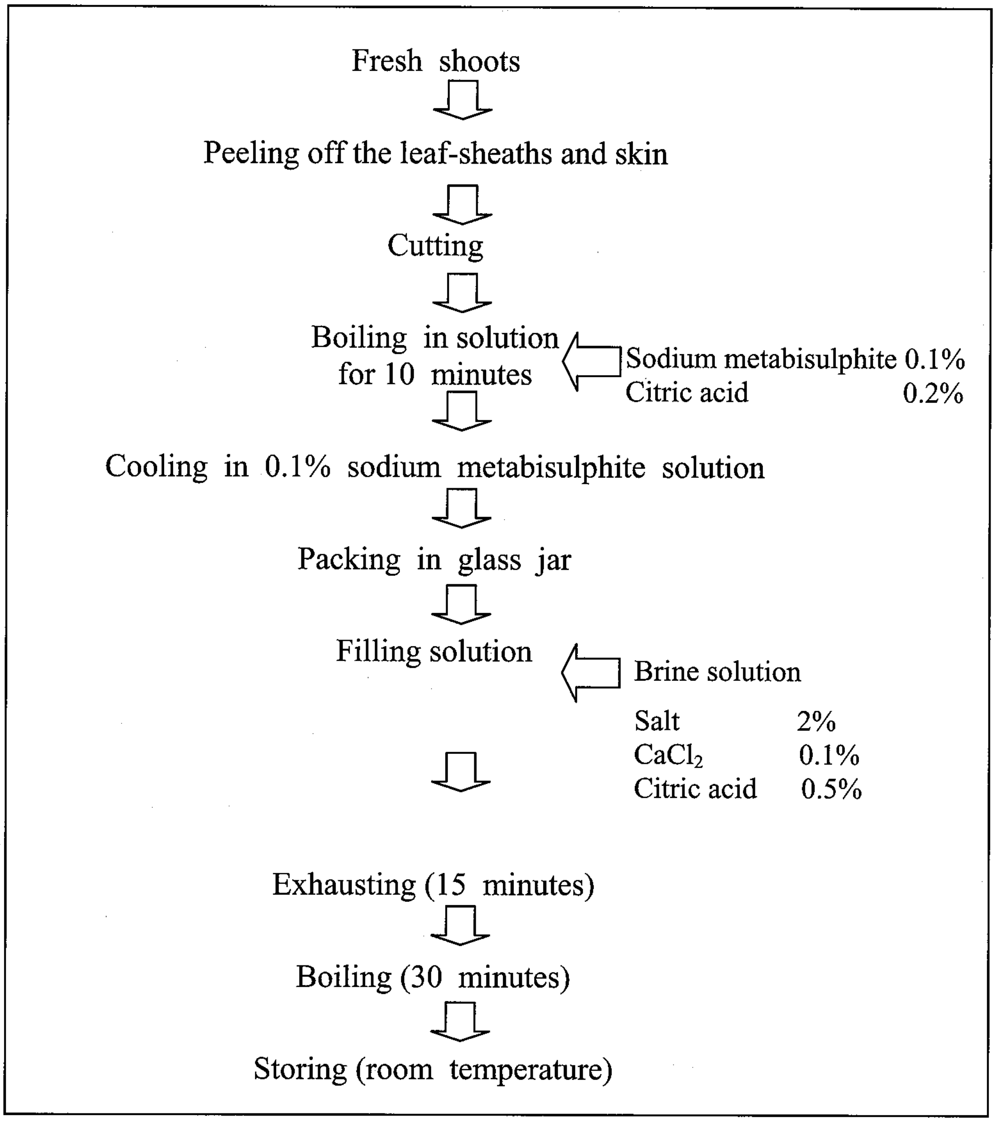

Figure 1. Bottling process of rattan shoots in brine solution.

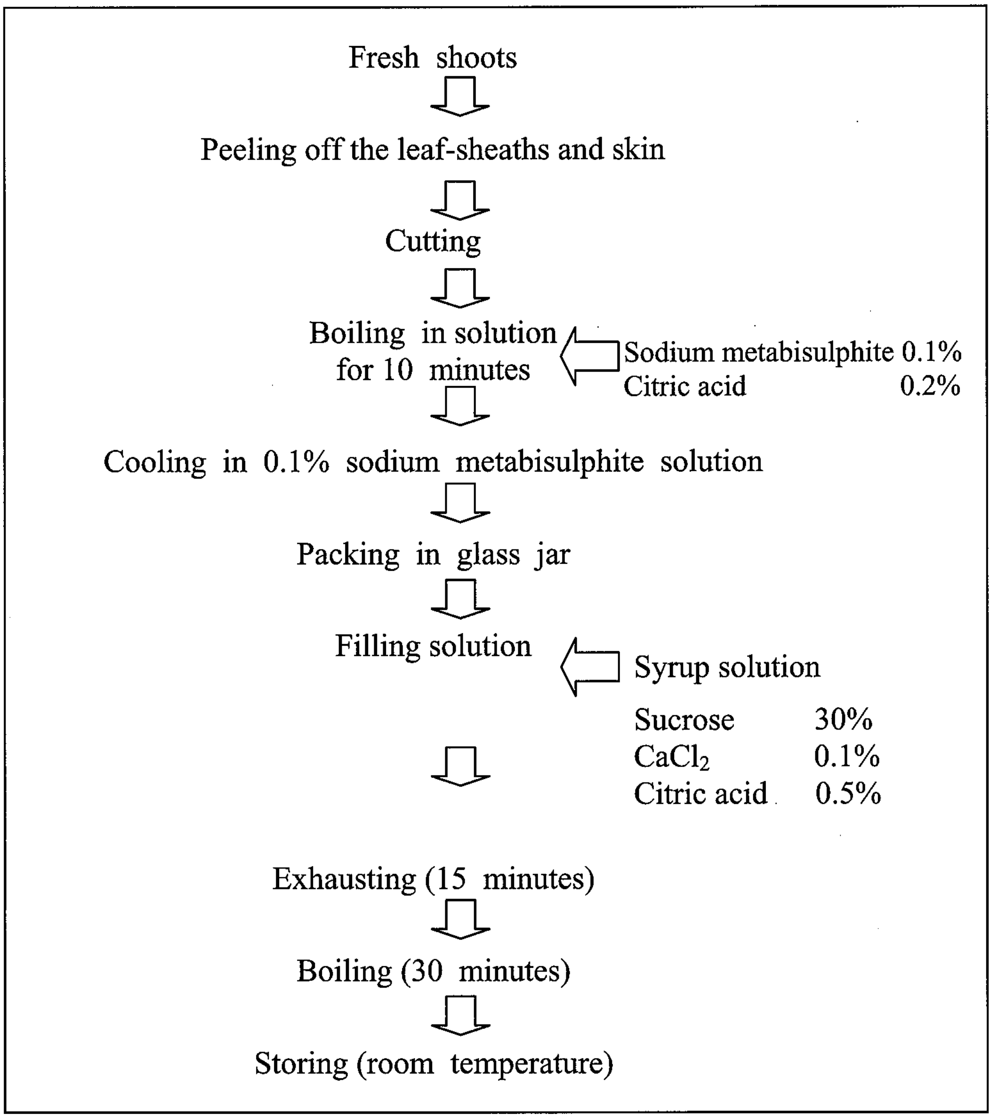

Figure 2. Bottling process of rattan shoots in syrup solution.

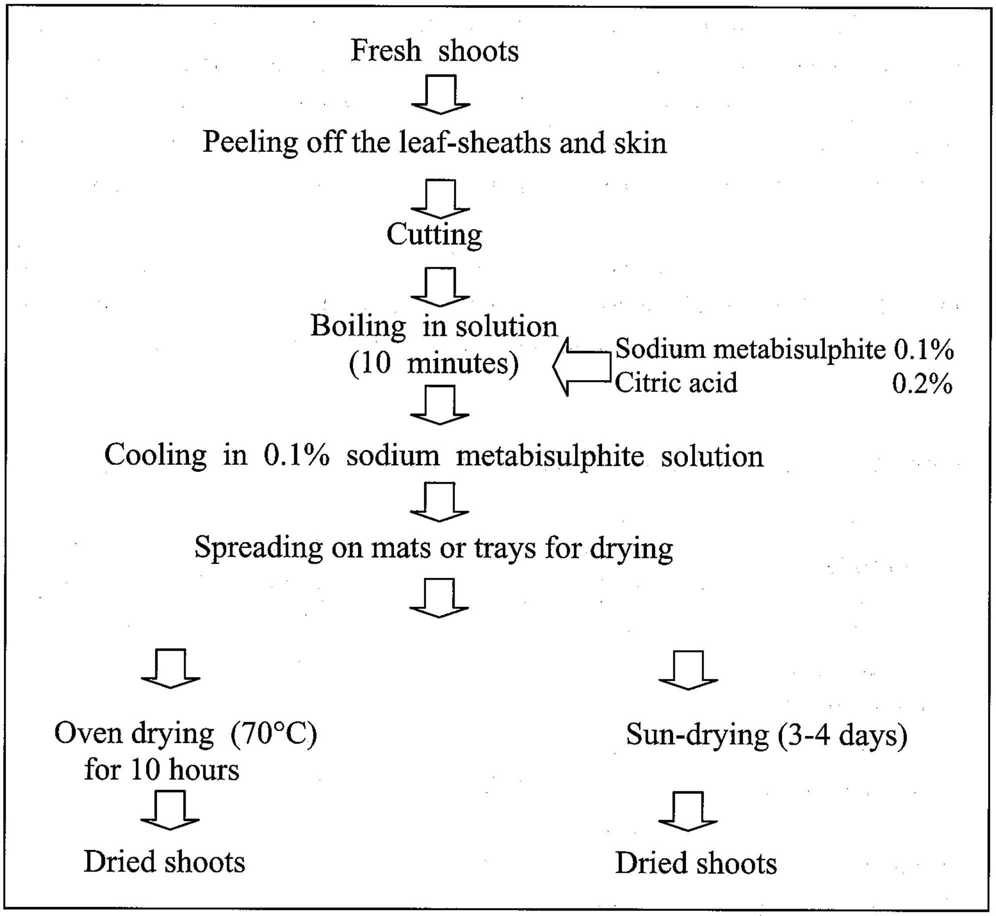

Figure 3. Sun-drying and oven-drying process.

Table 1. The results of microorganism investigation in rattan shoot products

Name	pH	Bacteria	Yeast and mould
Rattan shoots in syrup	4.3	Not found	Not found
Rattan shoots in brine	4.3	Not found	Not found

Note: Acid resistance bacteria (at 37 °C and 55 °C)
Department of Medical Science, Ministry of Public Health (2002)

Nutritive values of fresh and processed rattan shoots are presented in Table 2. It can be noticed that protein and fat in fresh shoots were slightly changed after processing. The energy (Kcal) of rattan shoots in syrup was higher than those in brine and the fresh ones, due to sucrose in syrup. The processed products received moderate mark scale in physical appearance by 50 random testers (Table 3).

Sun-drying and dehydrating of soft edible parts of the rattan shoot were about 10% of the whole shoots. The dehydration ratio was 8:1 and rehydration ratio was 1:3, while moisture content of the product was 6% (U.V. Moisture tester).

Table 2. Nutritive value of bamboo and rattan shoots in 100 grams edible part

Sample name	Bamboo shoot	Fresh rattan shoot	Rattan shoot in brine	Rattan shoot in syrup
Energy (Kcal)	30	32	28	80
Moisture (gm)	91.9	92	92	80
Protein (gm)	2.3	2.51	2.19	3.20
Fat (gm)	0.2	0.62	0.70	0.66
Carbohydrate (gm)	4.8	NA	NA	NA
Fibre (gm)	0.9	2.53	NA	NA
Vitamin A (RE)	NA	2	3	NA
Vitamin B1 (mg)	0.06	0.16	0.04	NA
Vitamin B2 (mg))	0.06	0.13	0.07	NA
Vitamin C (mg)	11	14	4	NA
Vitamin E (mg)	NA	0.45	0.85	NA
Sodium (mg)	NA	10.8	224.0	25.3
Potassium (mg)	NA	361	148	87
Magnesium (mg)	NA	48	33	26
Calcium (mg)	49	69	40	52
Ion (mg)	0.3	0.45	0.42	0.21
Zinc (mg)	NA	2.81	1.61	1.51
Copper (mg)	NA	0.31	0.14	0.20
Iodine (μg)	NA	2.4	41.5	4.4

Note : NA = Not analyse
RE = Retinal equivalent (Beta-Carotene)
Nutrition Division, Department of Health, Ministry of Public Health (2002).

Table 3. Sensory evaluation of rattan shoots in brine and in syrup

Product	Mean				
	Color	Odor	Flavor	Texture	Acceptance
Rattan shoot in brine	3.80	3.69	3.76	3.80	3.80
Rattan shoot in syrup	3.98	3.89	3.82	4.09	3.95

Note : 1 = very dislike
2 = slightly dislike
3 = neither like nor dislike
4 = slightly like
5 = like very much

ACKNOWLEDGEMENTS

I wish to thank the International Tropical Timber Organization (ITTO) for providing financial support for this project and the Nutrition Division, Department of Health, Ministry of Public Health for excellent laboratory works.

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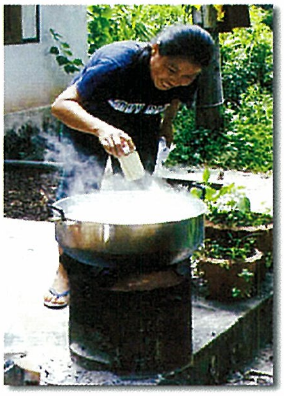
Annex Figure 1. Edible rattan shoots.

Annex Figure 2. Peeling off the leaf-sheaths and skin of rattan shoots.

Annex Figure 3. Blanching.

Annex Figure 4. Bottling.



Annex Figure 5. Exhausting of rattan shoots products.

Annex Figure 6. Sterilizing rattan shoots with boiling water.

Annex Figure 7. Sterilizing of rattan shoots.

Annex Figure 8. Bottled rattan shoots.

Annex Figure 9. Dehydration of rattan shoots.

Annex Figure 10. Dried rattan shoot products.

Rattan Protection

by

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PD24/00 Rev.1(I)

Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

Royal Forest Department
Thailand

October 2004

Rattan Protection

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Waai Pong (Calamus latifolius) and Waai Kam Puan (Calamus longisetus) were harvested from plantation in Krabi Province for the study on rattan protection to find suitable and practical methods of controlling staining fungi and insect infestation on rattan canes. Both species were treated with different processes. The results revealed that diesel oil curing at 105°C for 10 minutes showed the best result against fungi, followed by the mixture of diesel and kerosene (ratio 3:1) at 105°C for 20 minutes, diesel and palm oil (ratio 5:1 and 1:1) at 115°C for 20 minutes, and palm oil at 120°C for 30 minutes. There were less growth of mold and staining fungi on the skin of rattan canes which were good appearance with creamy white color. The immersion of rattan canes in 10% Boron compounds also showed a good appearance after peeling off the skins. In contrary, immersion of rattan canes in 1% Stemona solution for 24 hours could not protect rattan from staining fungi. For the infestation of insect, all treatments of both species and control (non-treated) were not attacked by any insect, especially powder-post beetle.

INTRODUCTION

Rattan is a plant of which the most parts are useful. The skin is good for weaving and also for binding material and furniture making, whereas the canes are used for making household material, furniture and sport equipment; the cores of the canes are for weaving and the leaves are used as curtains, roofing material, *etc.* The flexibility and multifunction of rattan raw material are demonstrated by diversity of the products. In general, all parts of rattan serve as basic raw material for making furniture and utensils which generate substantial income to the population and to the country as a whole. Rattan is widely recognized as an important domestic and internationally-traded commodity.

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A major problem faced by rattan processors is wastage during harvesting, cutting to size and infections by staining fungi and beetle attack. The loss due to wastage is estimated to be at least 30 percent. The cane quality and the product value on the local and international markets determine the choice of processing method. Post-harvest treatments are necessary to avoid defects and to increase processing possibilities and market value (Liese, 2002).

Degradation by such organisms can begin almost as soon as the canes are harvested. Staining fungi infect the cut portions or position of the stem where the epidermis is scratched during the pulling, dragging or peeling processes and beetle also attack during the rattan processing, storage and finished products. To minimize this, it has generally been realized that raw cane must be treated and processed without any delay.

Rattan is much liable to be infested by fungi and insect due to its high starch content. Fungal invasion can occurred within one day after cutting. Fungi that cause discoloration on the cane is classified as surface mold and staining fungi. Surface molds are caused by fungi which develop on the injured or cut portion of the cane surface. These can be easily scraped off. The stain may be yellow, green, blue, gray or black.

Staining fungi penetrate deep into the inner portion of the cane surface, utilizing starch and sugar, causing discoloration. Unlike surface molds, these cannot be scraped off. Discoloration may vary from blue, gray to black. It is estimated that about 20 percent of the harvested canes become stained. The staining fungi that has been isolated is *Botryodiplodia therobromae* (Jitkaew, 1990).

Rattan canes infested with powder-post beetles are noticed by the presence of bore holes and powdery mass on the surface. Power-post infestation occurs after cutting, during storage or even in the finished product.

The selection of preservatives and method of application is very important in ensuring that rattan is protected. The preservative must be toxic to all forms of destroying fungi and insects, readily available, permanently fixed in rattan, clean, colorless, odorless, safe to handle and non-poisonous to animal and humans, capable of penetrating rattan easily, soluble in water and should not affect the finishing of the end-product (Ashaari and Petty, 1999).

Boron compounds are a promising preservative to improve the service life of rattan while retaining its aesthetic value. Boron compound is locally available, and has been proven effective in preserving rubber wood and bamboo without affecting their natural appearance (Hong *et al.*, 1982, Sulthoni, 1985). This preservative has all the desired qualities except that are not permanently fixed in the treated material (Cockroft and Levy, 1973; Williams and Amburgey, 1987). Depletion is unlikely to be the problem of treated rattan since the treated material is not left in contact with water and the finished products are rarely used in contact with the ground.

Rattan oil curing is a very important part of rattan processing. It adds value to the raw material, preserves its unique qualities and improves its durability. Curing means the immersion of canes in a hot boil bath to prevent deterioration. Fresh stems cut to desired length and bundled are soaked in a given time in an oil bath within one-two days after harvesting. The oil penetrates the cane axially, while the radial penetration through the skin is almost nil due to its refractory anatomical structure. This process reduces the moisture content so that bio-deterioration is prevented. The rattan skin attains an ivory white color, which is much desired.

There are a number of investigations on the best methods of curing rattan canes. Different combinations of diesel oil, kerosene, palm oil, coconut oil are used, depending on availability and cost, and are applied at varying temperatures ranging from 80 to 150 °C for the duration of 10 to 60 minutes. After curing the stem are drained of excess oil and rubbed with sawdust, core or waste cloth to remove the waxy substances and silica deposits on the skin. During the subsequent sun drying, the color changes from green into ivory white.

The objective of this study is to find suitable and practical methods for controlling staining fungi and insect infestation of rattan.

MATERIAL AND METHODS

Rattan species: Waai Pong (*Calamus latifolius*).
Average diameter : 2.57 cm (2.2-3.2 cm)
Waai Kam Puan (*Calamus longisetus*)
Average diameter : 3.19 cm (2.6-3.7 cm)

These samples were harvested from rattan plantation in Krabi province. Rattan stems were cut into three parts (bottom, middle, and top), each of which was 1 m long for 3 replications per treatment; the total number of samples is 120.

The staining fungi abound by the environment can infest freshly cut cane within 24 hours after harvesting. Spores of the staining fungi are usually air borne or carried by insects. The entrances of infection are the ends or the abrasion or cuts on the cane surface. The fungi protection should be done as soon as possible after cutting, at least within 24 hours.

Powder-post beetle usually causes the problems in rattan storage, and also in the semi-finished products in rattan furniture shops. They do not attack the freshly cut cane, so there is no need to protect the beetle at the harvesting site.

Each treatment included 3 parts of each rattan species. After cutting, all samples were immediately treated with fungicides at the harvesting site. The fungicides and methods are as follows:

1) Paste both pole ends with calcium carbonate;
2) Paste both pole ends with mixture of calcium carbonate and turmeric;
3) Dip both pole ends with dithianon (fungicide);
4) Dip both pole ends with triforine (fungicide); and
5) Control (untreated).

The samples were transported to the processing site for being treated, 3 days after cutting, according to the treatments presented in Table 1.

For oil curing, the specimens were rubbed clean with rags to remove dirt from the surface immediately after boiling.

After treatments, all samples were air-dried in the shelter for about one month. The treated samples and controls were placed on supports in the shelter in field condition exposed to natural infestation by insects and fungi. The results of insects and fungal attack were evaluated by visual after 1, 3, 6 and 12 months exposure in the field before peeling the treated rattan skin for fungal inspection. The inspection of fungal attack was rated as follows:

0 – No damage;
1 – Slight attack (1-25%);
2 – Moderate attack (26-50%); and
3 – Heavy attack (51-100%).

Table 1. Methods of treatment

Treatment	Temperature (°C)	Duration
Oil curing		
1) Diesel	105	10 minutes
2) Palm oil	120	30 minutes
3) Diesel : Palm oil = 1:1	115	20 minutes
4) Diesel : Palm oil = 5:1	115	20 minutes
5) Diesel : Kerosene = 3:1	105	20 minutes
Immersion		
6) 1 % Stemona extract	Room temperature	24 hours
7) 10% Boron compounds	Room temperature	24 hours
8) Control	-	-

RESULTS AND DISCUSSION

The results of the study are presented in Table 2 and Figures 1 to 3. The results indicated that diesel oil curing at 105 °C for 10 minutes is the best treatment against fungi, followed by those with the mixture of diesel and kerosene (ratio 3:1) at 105 °C for 20 minutes, diesel and palm oil (ratio 5:1 and 1:1) at 115 °C for 20 minutes, and palm oil at 120 °C for 30 minutes. There were less growth of mold and staining fungi on the skin of rattan canes which were good looking with creamy white.

The treatment of immersion rattan canes in 10% Boron compounds also gave the good appearance after peeling off the skin. But immersion in 1 % Stemona solution for 24 hours could not protect rattan cane from staining fungi. Rattan canes were moist and there were more mold and staining fungi on the skin of rattan cane.

The results of inspection of both *Calamus latifolius* and *C. longisetus* were the same as presented in Figures 1 and 2.

It can be noticed that oil curing and immersion in 10 % Boron compounds were more effective protection against the fungal attack than those with pre-treatment. Due to oil curing process, food materials and moisture content in the cane were removed, and the factors contributing to fungi infestation were also reduced. It may be concluded that pre-treatment with calcium carbonate and fungicides could not protect rattan canes from the fungal infestation, since all the pre-treatments gave the same results for the immersion in 1% Stemona solution as shown in Figure 3.

Table 2. Fungi and insect infestation on treated rattan canes after 12 months exposure

Treatments	Mold infestation		Staining fungi infestation		Insect infestation
	Before peel	After peel	Before peel	After peel	
Calamus latifolius					
Oil curing					-
1) Diesel	1	0	1	0	-
2) Palm oil	3	0	3	0	-
3) Diesel : Palm oil = 1:1	2	0	2	0	-
4) Diesel : Palm oil = 5:1	1	0	1	0	-
5) Diesel : Kerosene = 3:1	1	0	1	0	-
Immersion					
6) 1 %Stemona extract	3	0	3	2	-
7) 1% Boron compounds	2	0	2	0	-
8) Control	3	0	3	2	-
Calamus longisetus					
Oil curing					
1) Diesel	1	0	1	0	-
2) Palm oil	3	0	3	0	-
3) Diesel : Palm oil = 1:1	2	0	2	0	-
4) Diesel : Palm oil = 5:1	1	0	1	0	-
5) Diesel : Kerosene = 3:1	1	0	1	0	-
Immersion					
6) 1 %Stemona extract	3	0	3	2	-
7) 1% Boron compounds	2	0	2	0	-
8) Control	3	0	3	3	-

Note: Rate of discoloration:
0-No damage 1-Slight attack 2-Moderate attack 3-Heavy attack

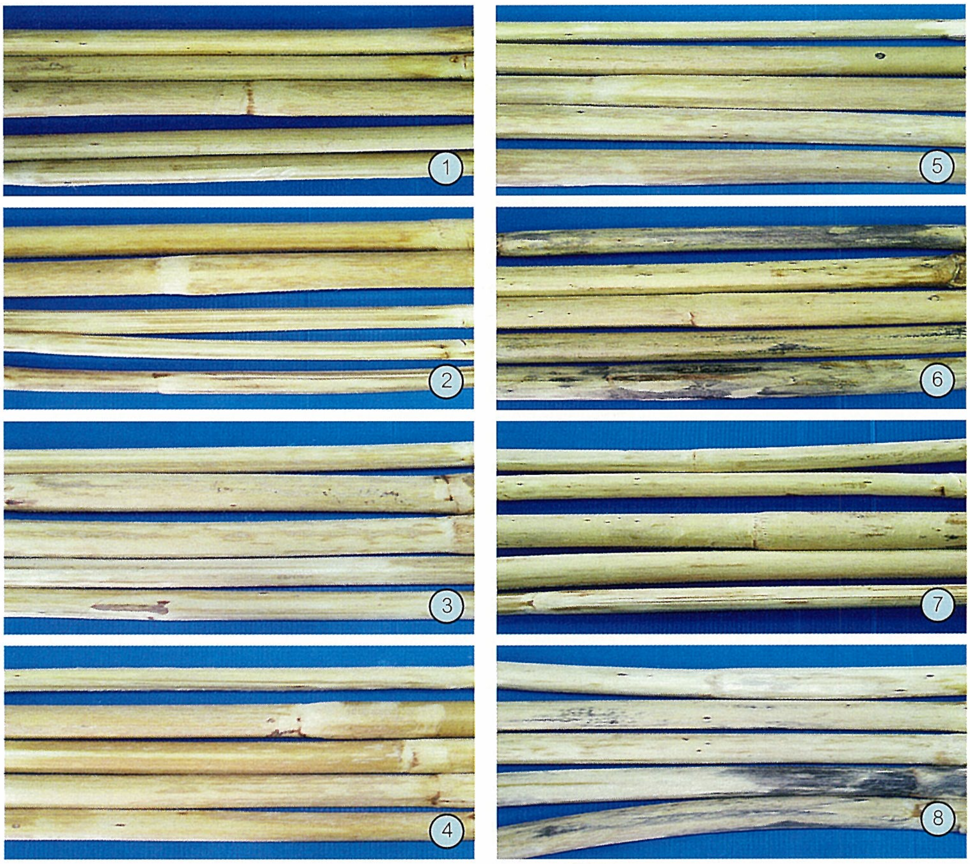
Oil curing

1. Diesel 105 °c 10 mins
2. Palm oil 120 °c 30 mins
3. Diesel : Palm oil ratio 1 : 1 115 °c 20 mins
4. Diesel : Palm oil ratio 5 : 1 115 °c 20 mins
5. Diesel : Kerosene ratio 3 : 1 105 °c 20 mins

Immersion

6. 1% Stemona Extract 24 hrs
7. 10% Boron compounds 24 hrs
8. Control

Figure 1. Texture and color of treated rattan canes (*Calamus longisetus)* after peeling their skin.



Oil curing

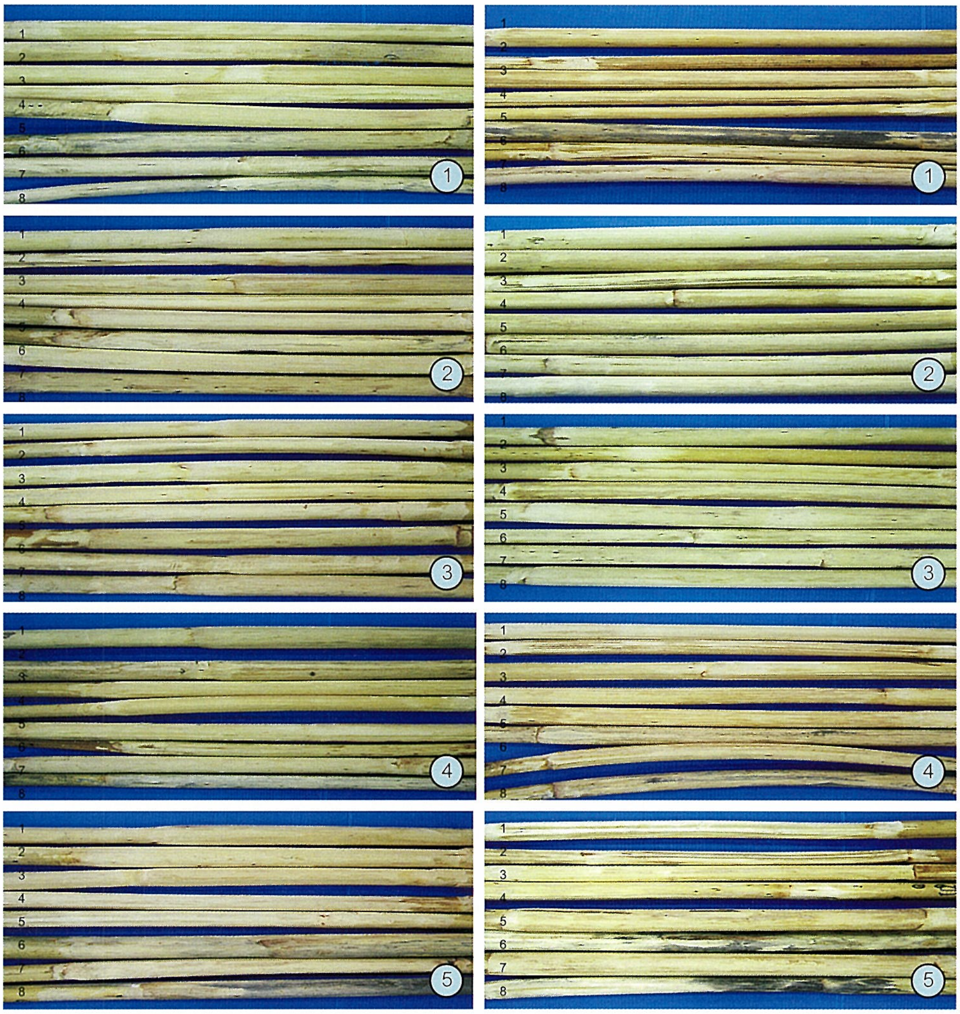
1. Diesel 105 °c 10 mins
2. Palm oil 120 °c 30 mins
3. Diesel : Palm oil ratio 1 : 1 115 °c 20 mins
4. Diesel : Palm oil ratio 5 : 1 115 °c 20 mins
5. Diesel : Kerosene ratio 3 : 1 105 °c 20 mins

Immersion

6. 1% Stemona Extract 24 hrs
7. 10% Boron compounds 24 hrs
8. Control

Figure 2. Texture and color of treated rattan canes (*Calamus latifolius)* after peeling their skin.

Calamus longisetus *Calamus latifolius*



① Calcium carbonate
② Calcium carbonate with Turmeric
③ Fungicide dithianon
④ Fungicide triforine
⑤ Control

1. Diesel 105 °c 10 mins
2. Palm oil 120 °c 30 mins
3. Diesel : Palm oil ratio 1 : 1 115 °c 20 mins
4. Diesel : Palm oil ratio 5 : 1 115 °c 20 mins
5. Diesel : Kerosene ratio 3 : 1 105 °c 20 mins
6. 1% Stemona Extract 24 hrs
7. 10% Boron compounds 24 hrs
8. Control

Figure 3. Treated rattan canes after pre-treatment with fungicides.

In case of insect infestation, samples of both species under all treatments and control were not attacked by any insect, especially powder-post beetle (*Dinoderus minutus*) even though this insect was presented at the experimental site by heavy infestation of some bamboo construction near the treated canes. Evaporation and odor of diesel and kerosene might perform as an insect repellent and food materials were removed by oil curing process. Nevertheless, Scolytid beetle was found on the samples treated with immersion in Stemona solution after three years of exposure while the others were free of attack.

CONCLUSIONS AND RECOMMENDATIONS

1) It is recommended that the rattan canes be immediately transported to processing site or within less than 3 days after harvesting before being treated by oil curing or immersion in boron compound solution.

2) It is not necessary to treat rattan cane with any fungicide at the collection site and it is also difficult to treat rattan canes at the collection site.

3) Pre-treatment with calcium carbonate and fungicides cannot protect rattan canes from fungal infestation.

4) As oil-curing treatment results in a good appearance of rattan canes, it is suggested that oil-curing with any oil proportions or any kind of oil are acceptable to be used. Oil price should be taken into consideration.

5. Immersion rattan poles in Boron compounds should be considered to be used as the alternative method since the oil price has been increased continuously.

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WILLIAMS, L.H. and T.L. AMBURGEY, *Integrated Protection against Lyctid Beetle Infestations. IV. Resistance of Boron-treated Wood (Virola spp.) to Insect and Fungal Attack,* Forest Products Journal 37 (2): 10-17, 1987.

Annex Figure 1. Preparation of rattan material in the present study, (1) *Calamus longisetus* in plantation, (2) – (3) cutting rattan canes to the desired length, (4) – (5) pasted the end of cane with calcium carbonate, (6) – (7) dip the end of cane in fungicide, and (8) bundles of the canes for transporting to the processing site.

Annex Figure 2. Treatment to rattan material in the present study, (1) – (2) oil curing treatment, (3) immersion in Boron compounds, (4) rattan canes before treatment, (5) rattan canes after oil curing, (6) treated rattan canes are air-dried vertically on the rack, (7) rattan canes after air drying, and (8) rattan cane is infested by staining fungi.

Mechanical Properties of *Calamus longisetus* Griff. and *Calamus latifolius* Roxb.

by

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Bounsong Sompoh

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Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

Royal Forest Department

Thailand

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Mechanical Properties of *Calamus longisetus* Griff. and *Calamus latifolius* Roxb.

Suchart Thaipetch[1] and Bounsong Sompoh[1]

The study on mechanical properties of Calamus longisetus Griff. and Calamus latifolius Roxb. was conducted in laboratory of the Royal Forest Department during 2003-2004. Canes of these two rattan species were collected from Naichong Seed Production Station, Krabi. Eight specimens were prepared from node and internode of rattan canes, each part of which was used in each test. Tensile, compression parallel to grain, hardness, density and moisture content were determined.

For C. longisetus, tensile, compression parallel to grain, hardness, density and moisture content of node part was 266 kg/cm^2/26.1 Mpa, 288 kg/cm^2/22.4 Mpa, 251 kg/2.48 kN, 303 kg/m^3 and 10.63 percent, respectively, whereas 404 kg/cm^2/39.6 Mpa, 262 kg/m^2/25.7 Mpa, 206 kg/2.04 kN, 328 kg/m^3 and 10.35 percent was respectively in case of internode part.

Tensile, compression parallel to grain, hardness, density and moisture content of node part of C. latifolius was 429 kg/cm^2/42.1 Mpa, 431 kg/cm^2/42.3 Mpa, 462 kg/4.57 kN, 425 kg/m^3 and 10.73 percent, respectively, compared with 327 kg/cm^2/32.1 Mpa, 389 kg/cm^2/38.2 Mpa, 450 kg/4.45 kN, 352 kg/m^3 and 10.00 percent of the internode part.

INTRODUCTION

Rattan is a kind of palm of Lepidocuryoides subfamily, in Palmae family. There are 25 genera and 500 species found in the world with natural distribution in the tropical zone (Smitinand, 1987). Rattan is regarded as a multipurpose plant in Thailand: canes are used for making different kinds of products, such as basket,

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chair and handicrafts, young shoots for favorite local food in northeastern part of the country.

There are several reports on mechanical properties of some rattan species. Bhat and Thulasidas (1991) studied tensile stress of 10 rattan species from southern India, *i.e.*, *Calamus nagbettai*, *C. thawilesii*, *C. gamblei*, *C. hochesianus*, *C. karnatakensis*, *C. lacciferus*, *C. psuedolensis*, *C. metizianus*, *C. rotang* and *C. travancernicus*. The maximum tensile stress of these 10 rattan species was 86.5, 45.9, 96.6, 57.2, 46.6, 44.8, 51.4, 22.5, 22.5 and 50.6 Mpa (megapascal), respectively. The maximum compressive stress of *C. nagbettai* was 33.6 Mpa, compared with *29.2 Mpa of C. thawilesii* and 29.9 Mpa of *C. gamblei*. In addition, mean maximum tensile stress at node and internode of two Malaysian rattans, *i.e., C. manna* and *C.caesius,* was 183.20 and 193.26 Mpa, respectively (Ismail *et al.*, n.d.).

The objective of this research was to study mechanical properties of *C. longisetus* and *C. latifolius*.

MATERIAL AND METHODS

Calamus longisetus Griff. and *C. latifolius* Roxb. canes were collected from Naichong Seed Production Station, Muang district, Krabi province. At RFD laboratory, canes of these rattan species were left in the shade in order to reduce the moisture content. Node and internode of those rattan canes were cut into desirable size and used as the samples for this study. There were five test types, *i.e.,* tensile strength, compression parallel to grain, hardness, density and moisture content test. Each test included eight samples of node and internode. Procedures for mechanical testing are as follows.

Tensile Strength Test

Router cut rattan barks at both side ends of each specimen with the width not more than 5 mm. Both specimen side ends were locked by grip and pulled until they were broken. The output of this test was the maximum crushing strength value used to compute tensile strength value by using the following formula.

$$T = \frac{P_{max}}{A}$$

Where T = tensile strength (kg/cm^2)

P_{max}	=	maximum crushing strength (kg)
A	=	broken area (cm^2)

Tensile strength value was then converted from kg/cm^2 to Mpa (megapascal) by using the formula:

$$T (Mpa) = 0.090807\ T (kg/cm^2)$$

Compression Parallel to Grain Test

The 4 : 1 ratio of length to diameter was used to prepare the samples for this test. For the samples of node part, the node should be at the center of the sample which was inserted into the equipment and compressed at 0.6 mm/min load. The output of this test was the maximum crushing strength value. The value was computed compression parallel to grain value using the formula shown below.

$$C = \frac{P_{max}}{A}$$

Where	C	=	compression parallel to grain (kg/cm^2)
	P_{max}	=	maximum crushing strength (kg)
	A	=	broken area (cm^2)

Compression parallel to grain value was converted from kg/cm^2 to Mpa using the same as that for tensile strength test.

Hardness Test

A 11 2 mm bullet with 10 mm/min pressure rate was applied to a side of the sample until half of the bullet immersed into the sample. The output of this test was hardness value and it was converted from kg to kN using the formula:

$$H_{(kN)} = 0.009807\ H_{(kg)}.$$

Density Test

The sample of 2 cm long was used to measure volume and weight. The density of the sample was computed using the formula:

$$D = \frac{W}{V} x\, 1{,}000$$

Where	D	=	density in kg/m^3
	W	=	sample air-dry weight (g)
	V	=	sample volume (cm^3)

Moisture Content Test

The same samples used for density test were weighed to find out their fresh weight and then dried in the oven at 105 °C until the weight was stable. The samples were weighted again to find out their dry weight. The moisture content was computed using formula:

$$\%MC = \frac{FW - ODW}{ODW} \times 100$$

Where %MC = samples moisture content (%)
FW = sample fresh weight (gm)
ODW = sample oven-dry weight (gm)

RESULTS AND DISCUSSION

The results of investigation on mechanical properties of *C. longisetus* and *C. latifolius* can be summarized as follows.

Tensile Strength

For *C. longisetus*, tensile strength of the node was 266 kg/cm^2/26.1 Mpa and 409 kg/cm^2/37.6 Mpa for the internode, compared with 327 kg/cm^2/32.1 Mpa and 431 kg/cm^2/43.2 Mpa in case of *C. latifolius* (Table 1).

Tensile strength of the internode was higher than that of the node. Moreover, tensile strength of these two rattan species was about the same as that of coconut, *i.e.,* 34 Mpa (Jullarerk, 2001).

Compression Parallel to Grain

Compression parallel to grain of the node and the internode of *C. longisetus* was 225 kg/cm^2/22.4 Mpa and 262 kg/cm^2/25.7 Mpa, respectively, while 437 kg/cm^2/42.3 Mpa and 387 kg/cm^2/38.2 Mpa were those of *C. latifolius* (Table 1).

Table 1. Mechanical properties of *Calamus latifolius* Roxb.

No.	Tensile				Compression				Hardness				Density(kg/m^3)		%MC	
	Node		Internode		Node		Internode		Node		Internode		Node	Internode	Node	Internode
	Mpa	kg/cm^2	Mpa	kg/cm^2	Mpa	kg/cm^2	Mpa	kg/cm^2	kN	kg	kN	kg				
1			40.0	408	49.6	505	44.2	451	7.53	762	5.47	553	379	434	10.44	10.14
2	38.5	392			46.2	471	41.2	420	3.53	357	2.67	270	460	321	10.59	9.85
3	43.8	447			46.7	476	30.8	314	5.61	568	5.17	523	436	301	11.16	10.00
4	48.2	491			47.4	484	37.8	386	2.96	299	2.93	297				
5	38.8	395	28.4	290	41.6	424	39.3	401	3.35	339	2.20	223				
6	41.1	420			38.6	394	42.4	432	3.97	401	4.42	448				
7					37.8	385	33.2	338	3.30	333	7.61	770				
8			27.8	284	30.3	309	36.3	370	6.31	638	5.12	518				
Mean	**42.1**	**429**	**32.1**	**327**	**42.3**	**431**	**38.2**	**389**	**4.57**	**462**	**4.45**	**450**	**425**	**352**	**10.73**	**10.00**
SD	**4.0**	**41**	**6.8**	**70**	**6.5**	**66**	**4.6**	**47**	**1.69**	**171**	**1.79**	**182**	**42**	**72**	**0.38**	**0.15**

Table 2. Mechanical properties of *Calamus longisetus* Griff.

No.	Tensile				Compression				Hardness				Density(kg/m^3)		% MC	
	Node		Internode		Node		Internode		Node		Internode		Node	Internode	Node	Internode
	Mpa	kg/cm^2	Mpa	kg/cm^2	Mpa	kg/cm^2	Mpa	kg/cm^2	kN	kg	kN	kg				
1	22.8	232	42.0	428	18.5	188	22.6	230	2.84	287	2.51	254	232	256	10.44	9.07
2	36.8	375	43.5	444	20.3	207	23.4	239	2.60	263	2.41	244	267	450	11.35	11.07
3	22.0	224	28.1	286	19.2	196	26.4	270	3.11	315	1.86	189	410	279	10.11	10.91
4	19.5	199	38.5	392	20.6	210	25.9	264	2.16	218	2.13	216				
5	28.5	290	45.2	461	28.1	286	30.0	306	2.55	258	1.76	178				
6					27.2	278	32.8	334	1.62	164	1.38	139				
7					15.9	162	15.0	153	3.14	317	2.95	298				
8	27.1	277	40.6	414	29.2	298	29.4	300	1.80	182	1.31	133				
Mean	**26.1**	**266**	**39.6**	**404**	**22.4**	**228**	**25.7**	**262**	**2.48**	**251**	**2.04**	**206**	**303**	**328**	**10.63**	**10.35**
SD	**6.2**	**63**	**6.1**	**62**	**5.0**	**51**	**5.5**	**56**	**0.57**	**58**	**0.57**	**58**	**94**	**106**	**0.64**	**1.11**

The results indicated that compression parallel to grain of node and internode within species was similar. Generally, compression parallel to grain of node and internode of *C. latifolius* was higher than that of *C. longisetus*. Based on RFD standard, the compression parallel to grain of rattan was at the same range as that of medium hardwood species, *i.e.,* 300-500 kg/cm^2 (Tonanon *et al.*, 1985).

Hardness

The hardness of the node and the internode of *C. longisetus* was 251 kg/2.48 kN and 206 kg/2.04 kN, respectively, compared with 462 kg/4.57 kN and 450 kg/4.45 kN of *C. latifolius* (Table 1).

The hardness of the node and the internode within species was rather indifferent. It can be noticed that the hardness of both parts of *C. latifolius* was higher than that of *C. latifolius* which were as high as the hardness of *Barassus flabellifer*, 435 kg (Tonanon *et al.*, 1985).

Density

Density of node and internode of *C. longisetus* were 303 and 326 kg/m^3, respectively. Meanwhile, density of node and internode of *C. latifolius* were 425 and 352 kg/m^3, respectively (Table 2).

The results were shown that density of both rattan species were less than 500 kg/m^3. According to Tonannon *et al.*, (1985), these rattan species are classified as low density or lightweight wood.

Moisture Content

For *C. longisetus*, moisture content of node and internode were 10.03 % and 10.35 %, respectively. While those parts of *C. latifolius* had 10.73 % and 10.00 % of moisture content, respectively (Table 2).

The moisture content of both rattan species was similar and these values were classified as dry moisture content condition for these tests.

CONCLUSIONS AND RECOMMENDATIONS

The results of the study on mechanical properties of the node and the internode of two rattan species, *Calamus longisetus* and *C. latifolius*, can be concluded as follows.

For *C. longisetus*, tensile strength of the node and the internode was 266 kg/cm^2/26.1 Mpa and 409 kg/cm^2/37.6 Mpa, respectively, whereas those *of C. latifolius* were 327 kg/cm^2/32.1 Mpa and 431 kg/cm^2/43.2 Mpa.

The compression parallel to grain in case of *C. longisetus* was 225 kg/cm^2/22.4 Mpa and 262 kg/cm^2/25.7 Mpa, respectively, compared with 437 kg/cm^2/42.3 Mpa and 387 kg/cm^2/38.2 Mpa for *C. latifolius.*

The hardness of *C. longisetus* was 251 kg/2.48 kN and 206 kg/2.04 kN, respectively, while those of *C. latifolius* were 462 kg/4.57 kN and 450 kg/4.45 kN.

For *C. longisetus,* the density of two parts of rattan cane was 303 and 326 kg/cm^3, respectively, compared with 425 and 352 kg/cm^3 in case of *C. latifolius.*

For *C. longisetus*, the moisture content of the node and the internode was 10.03 % and 10.35 % respectively, compared with 10.73 % and 10.00 % moisture contents in case of *C. latifolius.*

Mechanical properties of the node and the internode of *C. longisetus* and *C. latifolius* were similar to those of medium hardwood. Despite low density and light-weight wood, the canes were more suitable for making furniture and other house and farm hardware.

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SOCIO-ECONOMIC ASPECTS OF SMALL RATTAN CO-OPERATIVES

A Case Study at Baan Kumphangsaen, Jombung District, Ratchaburi Province

PD 24/00 Rev.1(I)

Promotion of Sustainable Utilization of Rattan from Plantation in Thailand

June 2005

Socio-economic Aspects of Small Rattan Co-operatives at Baan Kumphangsaen, Jombung District, Ratchaburi Province

RATIONALE

Thailand is situated in the tropical region where a vast biological diversity occurs. People living in different parts of the country used to spend their lives upon the natural resources especially forest resources that reflect typical way of life of the Thai people at both national and local levels. In the former time, "teak" (mostly harvested from natural forest) was on the top of the list of Thailand's exports, but not during the past 30 years. Despite less flow of timber from natural forests particularly after the logging ban in 1989, several non-wood forest products (NWFP) have been recognized as the treasure of natural forests from which rural people enjoy using for their daily life.

"**Rattan**", one of the most important NWFP, plays an important role in the way of life and culture of Thai society. It has been used as a tool and fastening material for housing construction. This can be seen from the old-styled weaving houses. Moreover, rattan has been used in various ceremonies and rituals. It was also used as a tool to whip the offender for punishment. Not only canes are used for different purpose, shoots of some rattan species are edible and people in different regions have their own typical recipe for rattan shoot cooking. Due to the bitter taste, some people believe that rattan shoot has medicinal properties.

Normally, rattans are found in peat swamp, dry-dipterocarp forest, and mix-deciduous forest throughout the country. In the former time, rattan could be harvested from natural forest without law enforcement, except in case of Waai Takha Thong (*Calamus caesius*). However, not long afterwards, due to the widely used and increasing in demand, the numbers of rattan in natural forest had been decreased rapidly. Until 1987, the government had promulgated the law for all kind of rattan become prohibited and caused difficulty to harvest from natural forest. While rattan raw material becoming shortage, rattan products of Thailand become popular in the worldwide. There is a need to import rattan raw materials from neighboring countries to support rattan based industries in Thailand. This caused an increasing in value imported each year. At present, rattan in those exporting countries tends to decrease gradually and caused higher price. Thus, many rattan-related organizations have tried to find the way to solve the problems on the shortage of rattan raw material. The Royal Forest Department, with the support from ITTO, has set up the project on **Promotion of Sustainable Utilization of Rattan from Plantation in Thailand.**

The Project aims to develop and disseminate the knowledge on sustainable management of rattan plantation and to find appropriate technology for efficient utilization of rattan in Thailand. The Project also intends to promote socio-economic development in conjunction with forest conservation. The most specific objective is to study and develop the techniques for sustainable management of rattan plantation and transfer such techniques to the rural people and encourage them to efficiently utilize rattan shoots and canes by making value-added products.

The project had invited experts from Division 8, Industrial Promotion Department to train and shares their experience on rattan weaving product and furniture making to the group of people from Baan Kumphangsaen, Moo 7, Jombung district, Ratchaburi province where the people have basic knowledge on simple rattan basket making, but lack of skills for their product improvement.

The first training was on **Rattan Weaving and Furniture Making** held during 18 August to 2 October 2003 with 34 participants. After the training, some from the group had continued their work and after 6 months before being provided with additional knowledge and skills from the experts of Bang-Sai Arts and Crafts Center, Ayuttaya province. This enhanced the group to develop their skills and created better products which were widely accepted in the market. In early 2005, the products from the group were sent to the OTOP contest and finally awarded the prize of 4-star product.

According to readiness and potential of the group, the Project organized another training on skill development and product design by integrating metal and rattan for the furniture products. Since rattan raw material has dramatically been diminished and become more expensive, this rattan-metal integration could save the use of rattan raw materials while the design of new products placed a higher price. The course was held during 20 April to 5 May 2005 under the title: **New Design of Rattan Furniture Making**, with 20 participants. The training course included the preparation of metal structure covered with rattan slats, calculation of product prices, marketing, and development products for export. The training was aimed to develop the participants' skills and ideas for rattan furniture production in the future.

GENERAL INFORMATION ABOUT THE GROUP

Baan Kumphangsaen is a small village established about 30 years ago. The villagers migrated from Kumphangsaen district, Nakhorn Prathom province, and the village is named after their former home site. There are 20 households in this village and most of them are kindred. Main livelihood of the population is agriculture, the main crops of which are pineapple, cassava and sugar cane.

In November 2002, the housewife group of about 15 persons at Baan Kumphangsaen established a group of weaving product of rattan fruit-basket and the gift-basket. The purpose was to get additional income after the farm work. They could sell their baskets at the price of 30 – 35 Bath per piece.

In August 2003, the Royal Forest Department, by the project **Promotion of Sustainable Utilization of Rattan from Plantation in Thailand**, invited resource persons from Division 8 of the Industrial Promotion Department to conduct a training course on **Rattan Weaving and Furniture Making** for the group members and interested persons. After the training, some participants continued to work on their career while the others were back to the farm due to the products income from the farm was the main income for their living while rattan product was still not well known and took time to sell out.

Based on uncertain situation, Ms. Kanokwan Pethsaithong, the group leader, had realized that the group members might use the knowledge from the training ineffectively. Therefore, she tried to encourage the members to invent and develop the new products to reach the standard and seek for an opportunity to sell the products. Firstly, she did promote the products via regional organizations that contacted with the group and tried to present the products in the temporary commercial booth at various festivals and ceremonies in Ratchaburi and nearby provinces. Thereafter, the order rate was increased and the situation improved. The members who formerly attended the training started to come back. The group have become well known and been accepted as the products received the OTOP's award for 4-star products.

At present, there are 20 members in the group at Baan Kumphangsean producing rattan furniture, utensils, and house-decorated items including the development of new designs of the product to serve the market demand. The group currently has approximately 150,000 Bath as a revolving fund from the loan from the Bank of Agriculture and Cooperatives and from members' fund raising.

Administrative and management activities of the group are divided into two parts, *i.e.*, production and quality control. There are 8 members who work full-time, the rest being part-time. The experienced members will take care of marketing and control, while those with less experience work for quality products. Sale manager will take care for marketing, product release, product pricing, raw material procurement and work closely with production group on product design. The administrative group will coordinate within group and other related organizations.

Production processes and benefit-sharing system can be divided into 3 categories as follows.

1. Members are paid on the piece-rate basis.
2. Members are paid on daily basis, *i.e.*, 100 Baht/day for particular assignment.
3. Members take rattan raw material from the group to work at home and sell the products to the group. These members are inconvenient to go to work on the site and want to spend their free time from daily work to earn additional income.

Working process of the group is still old fashioned with local equipment and those donated by the Project.

The group has a shop at Chatuchak 2 Weekend Market in Bangkok's Meenburi district. Some products are available at some shopping centers in Bangkok. Some products are made to order, while some are presented at the fairs, festivals and various events. Ms. Supranee Petchsaithong is responsible for these sale activities.

The group receive uncertain income due to the beginning stage of the business. However, external support and encouragement from several organizations have initiated the group to be able to accumulate their own properties in the form of building, devices and technology.

This study includes the analysis of socio-economic factors affecting to the performance of group to find the trend to promote other groups in the future. Semi-structure interview had been conducted by pre-identifying the person in charge of major information together with participate observation. Results obtained can be used for the SWOT analysis to determine the strengths, weaknesses, opportunities, and threats of the group. The results of the study can be summarized as follows.

FACTORS AFFECTING THE SUCCESS OF THE GROUP

1. **Leader characteristics:** The leader should dedicate his/her time for the benefit of the group. He/she should have a great effort in presenting the products to the market by all means and is enthusiastic in the innovative ideas and knowledge. Other characteristic for the successful practitioner is an ambition to create the new and better things.

2. **Cooperation within the group:** All members (full time and part time members) should be united in making the products whenever the group needs their help. When there is a large order during the season that labors are needed to make a big lot of products in time, all members should come and work together at full efforts.

3. **Administration:** Good administration is a key factor to success. The Baan Kumphangsaen rattan production group has a clear description of the job and the persons in charge. There is a good coordination among the members. Benefit sharing is fair and transparent that is acceptable among the members.

4. **Social capital:** The word "capital" came from an economic term that represent valuable items that can and cannot be appraised to currency exchange. Those that cannot be appraised to currency but necessary to human life is natural resources including what human created such the four requisites for comfort, money, asset, knowledge and experiences, social structure, relationship, and rule and regulation for the people in community to live together. In case of Baan Kumpangsaen rattan production group, an important capital is the kindred relationship which have the linkage from old generations and create specific type of relationship. The members in the group are deep in trust, difficult to contradictory, high unity and cooperation which are beneficial to the group.

5. **Support from various related organizations:** Within a certain time the group will not be successful at this level without the support from related organizations, especially the support from the **Promotion of Sustainable Utilization of Rattan from Plantation in Thailand Project** since the beginning. The Project has provided the group with the knowledge, technology, some raw

materials, and devices in all training courses. The Project also follows up the group activities by sending staff once every 2 months for monitoring and evaluation.

REVIEW OF STRENGTH, WEAKNESS, OPPORTUNITY AND THREAT (SWOT ANALYSIS)

Strength of Baan Kumpangsaen rattan production group is a human resource. This group has a powerful leader who is eager to present the products. All members are united and ready to help each other with open mind and enthusiasm to obtain new ideas and technology.

Weakness of the group is a lack of information and experience in marketing. Target group of customer is still ambiguous. They cannot determine the direction of group or product and also direction of their skill that will lead to their own brand name. At this moment, the group is not so well known in the field yet and the transportation of raw material to the group is not so convenient due to the production site is far from the market.

Opportunity of the group is the support from related organizations in term of knowledge, technology, devices and raw materials. Moreover, nearby communities make other kind of products, providing an opportunity to create a joint business.

Threats to the group are the shortage and the increase in price of rattan raw materials and the volume of import from neighboring countries tends to decline and becomes more and more expensive in the future. There is no specific policy to raise rattan resource as a substitute for import materials. Skills of craftsmanship are also a serious threat to the future of rattan handicraft production.

COMMENTS ON PERFORMANCE OF THE GROUP

1. Try to encourage the use of raw material inside the country and the use of integrated materials to reduce the cost, but increase value-added and provide the choices for customers.

2. Need to train the new generation to replace the old ones, as skills and techniques should be continuously developed.

3. Develop designs to meet the target demand. Always study on new direction of the designs and try to develop to match the taste of the customers.

4. Promotion of market in all aspects. The activities such as joining the product competition festival, public relations via web-sites of various organizations, and taking the product to present at some fairs in Bangkok.

5. Develop network connection to make the people within the group or cluster for the convenience to contact with each others and with customers.

COMMENTS ON FUTURE PROMOTION OF RATTAN-RELATED ACTIVITIES

1. Activities to be promoted should meet the real requirements of the group. Due to the big investment, the promotion should be cost-effective and resource use efficiency.

2. Monitoring and evaluation after the training are important. It will help make the group proud, being encouraged and enthusiastic to work. Moreover, this step will prevent and solve the problems that might occur to the group.

3. Provision of technology, devices and financial support is a serious concern for the sustainability of the group's activities. An access to the loan is also a good alternative.

CONCLUSIONS

The **Promotion of Sustainable Utilization of Rattan from Plantation in Thailand Project** organized the training on **Rattan Weaving and Furniture Making** to the people in Baan Kumpangsaen Moo 7, Kaem-onn sub-district, Jombung district, Ratchaburi province during 18 August to 2 October 2003. After training, the group members continued their work and obtained the 4-star award at the OTOP (One Tambon One Product) Product Contest. This means that the quality of the products is officially guaranteed. Thereafter, the Project organized the training course on **New Design of Rattan Furniture Making** in order to enhance the capability of the group.

Following are the factors contributing to the success of Baan Kumpangsaen rattan furniture and rattan weaving group.

1. **Leader characteristics.** The enthusiasm on new ideas and the attempt to present the product including an offering mind to make everything better.

2. **Unity within the group.** All members were united and willing to work for the group.

3. **Management within the group.** The group members share their jobs and responsibilities. The benefit sharing is fair and transparent.

4. **Social capital, kindred, and relationships** among community members result in good relationship, trust, cooperation, and unity within the group.

5. **External support from related organizations.** The support includes not only training, technology and devices but also monitoring and evaluation that encourage the group to work with what they have learned.

ANNEX

Typical rattan baskets before training course

Weaving for rattan baskets

Preparing of furniture structure

Steaming of rattan cane

Soldering pieces of metal for furniture structure

Spraying of color before weaving

Weaving of rattan over metal structure to make integrated product

Rattan products

A set of metal-rattan integrated products

Some of metal-rattan integrated products

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